Jute and its Manufacture

BY

H. R. CARTER

Author of "Modern Flax, Hemp and Jute Spinning";
"Rope, Twine and Thread Making," &c., &c.

London

JOHN BALE, SONS & DANIELSSON, LTD.

OXFORD HOUSE

83-91, GREAT TITCHFIELD STREET, OXFORD STREET, W. 1.

CONTENTS.

LIST OF ILLUSTRATIONS.

JUTE AND ITS MANUFACTURE.

CHAPTER I.

JUTE AND ITS MANUFACTURE.

It is an extraordinary fact that only about ninety years ago the jute industry, which now ranks second in importance to cotton as a raw material of British manufacture, was practically non-existent.

There can be no doubt that jute was known to the natives of India from comparatively remote periods, but from the confusion which existed down to the present century in the words of *sunn*, *pat* or *patta*, *changa* and hemp, &c., names applied to certain Indian fibres, it is difficult to determine for certain many of the fibre-yielding plants referred to by ancient writers. The probability is that sunn-hemp (the fibre of the *Crotolaria juncea*) was better and earlier known to the ancient Hindus than jute and that the true hemp (*Cannabis sativa*) was known to them, if not brought to India by their invading and conquering ancestors. It is almost safe to assume, says Sir George Watt, that in very remote times sunni patta and changa were synonymous and generic terms for fibre and coarse cloth without much regard to the plant from which the fibre was obtained. If so, about the beginning of the present century, the word pat became fixed and associated with the fibre of *Corchorus olitorius* and *C. capsularis*. Prior to that date, Government returns of export from India mention hemp fibre; this must have been either *sunn* or jute, since the true hemp fibre has not been cultivated for centuries at least, and modern experiments have shown that the plant is not capable of cultivation as a source of fibre in the plains of India.

Dr. Roxburgh used the name jute for the first time in 1795, describing the fibre to the directors of the East India Com-

pany as "the jute of the natives." Probably the term thus used was the phonetic rendering of the Cuttack vernacular *jhat*, with which Dr. Roxburgh had acquired familiarity in the extensive rope works which the company had in that district. However that may be, it is not till 1828 that we find jute mentioned commercially.[1] Of course, it had been grown for centuries in the hot, damp climate of Eastern Bengal, and had been woven into coarse fabrics for bags and cloth, but it was not until advancing civilization brought a demand for clothing that jute was generally utilized among the poorer classes, who little more than half a century ago were largely clad in jute cloth of home manufacture, such as at the present day is used by the aboriginal tribes.

Some attempts on a small scale to utilize jute fibre for the manufacture of carpets were made at Abingdon, in Oxfordshire, about the year 1820, or soon after it, while jute was being imported for cordage; but the first commercial mention of the word jute is in the Customs returns of the exports for 1828, when 364 cwt. were sent to Europe. It was at Dundee, which had for a considerable time been one of the seats of the linen industry, that in 1832 or 1833 the spinning and weaving of jute fibre first began to give promise of commercial success. Thomas Neish, a Dundee merchant, received a small consignment of jute from London about the year 1822. He endeavoured to induce some of the flax spinners to try it over their machinery, but could not get them to make the attempt, and it lay in his warehouse for a long time without buyers at any price, until at length he got Messrs. Bell and Balfour, flax spinners, to consent to take it at £11 per ton. This firm experimented with it to a small extent between 1825 and 1826, but were unable to spin it into yarn, and the bulk was ultimately disposed of for the purpose of being made into door mats and similar articles.

The nature of the fibre was unknown, and the spinning machinery then in use ill-adapted to meet its needs. Some years elapsed before any further attempts were made to spin jute by machinery, and again the same parties were, to some extent, the pioneers of the manufacture. In 1832 Mr. Neish got another consignment of jute from James Scott, of London, and this parcel may be called the foundation of jute manufacture in Dundee; he succeeded in getting the firm of Balfour and Meldrum, successors to Bell and Balfour, who had tried the fibre before, to take a small parcel of it, which they experimented upon at the Chapelshade Works. These experiments

were not made upon an extensive scale, but they were this time persevered in assiduously, and ultimately proved successful. From about the end of that year a little jute was spun by the firm regularly. The principal instrument in the introduction of jute into the trades was James Watt, jun., merchant of Dundee, who made a trial of ten bales, purchased from Mr. Neish in July, 1832, at £19 per ton. In 1883 Mr. Neish received other parcels of the fibre for sale, and from that period continued in the trade, often dealing very largely in the article. He was thus the first merchant to offer the jute fibre for sale in Dundee, and it was through his persevering efforts to get parties to try the fibre that it was introduced into the trade of the town, now the principal seat of the jute manufacturing industry in Great Britain.

When the resources of the rich plains of India, Burmah and China, and later on of America, Australia and Egypt, were by the British mercantile marine made available for the supply of corn, a big demand sprang up for bags, and thousands of rough gunnies of native India manufacture were greedily bought up. The high price obtained was a powerful incentive to increased activity, and thus the gunny bag trade rapidly became a recognized part of Bengal peasant's work. Later, however, European machinery began to compete with native manual labour, and in due time gained the day, the agriculturist finding that his time would be more profitably spent preparing an extra quantity of the fibre than in manufacturing bags to compete with steam and mechanical appliances. The preparation of fibre thus speedily outstripped the demand for home manufacture, and a large export trade was established with Dundee in raw jute. Thus transferred from its original home, the gunny bag trade took a new start in Dundee, and down to the year 1854 little or no effort was made to improve the Indian manufacture by the use of European machinery. In that year, however, the Ishera Yarn Mills Company was established at Ishera near Serampur, by Mr. George Ackland, a large owner of coffee plantations in Ceylon and a non-official member of the Legislative Council of that island. These mills were afterwards called the Ishera Company, Ltd., and later the Wellington Mills. Three years later, in 1857, the Borneo Company, Ltd., a company originally established to exploit the Island of Borneo, founded the mills now known as the Barnagore Mills. In 1863-64 the Gouripur Jute Factory came into existence. Following these, factories sprang up rapidly in every direction around Calcutta. In the Trade

Returns for 1869-70 the exportation of manufactured jute was 6,441,863 gunny bags, manufactured by hand and power looms, and brought into competition with the Dundee bags. This trade developed steadily, and ten years later over 59,508,000 gunnies were annually exported from India.

The basis of the present extensive manufacture of hessians in Dundee was laid at the time of the American Civil War, which made cotton so high in price that there was a search for cheaper materials, and it was found that jute was adapted for bags and many other articles for which cotton had until then been used. The Dundee manufacturers promptly took advantage of the opportunity thus presented, and the large fortunes then made enabled them to put the industry on a sound footing.

For a while Dundee had a complete monopoly of the jute manufacturing business. Mills then began to spring up on the Continent, and Calcutta began to manufacture its home product, and on coarse goods, with its cheap labour and long working hours, has had great success. Both Indian, Continental and American mills have made great progress during the last twenty years, and their number of spindles and looms is still increasing, while those in Dundee have until recently barely held their own. There are now at least forty-three mills at work in Bengal and one in Bombay. The number of looms now working is at least 34,500. The actual consumption of jute in India has doubled itself in the last fifteen years, while the foreign exports of raw jute have continued to increase very steadily.

India now consumes nearly three times as much jute as Dundee, and the Continent twice as much, and the American mills rather over half as much.

The raw jute required to supply the world is about as follows: United Kingdom, 1,350,000 bales; and the Continent, 2,600,000 bales. The annual consumption of Europe is about 3,950,000 bales.

India uses about 5,000,000 bales per annum, and America 6,000,000 bales. The total consumption per annum may be taken at approximately 1,900,000 tons, value £22,800,000.

In Calcutta a weaver's wages are about equal to what they are in Scotland, but Scotch hands of other sorts earn from one-half to two-thirds more than the same class of hands do in Calcutta. In India, however, unskilled labourers get very little. It is said that to produce a finished piece of jute cloth in India, seven persons are required to do as much work as

three at home. However, the class of work turned out is not the same.

Some of the Indian jute factories are immense. There is an establishment at Barnagore, near Calcutta, which employs more than 4,500 workmen and manufactures annually more than 14,000,000 lb. of jute.

In the provinces where jute is raised, the distaff is in every hovel. The Mohammedans, deterred by some religious scruple, restrict themselves to the manufacture of cotton; but among the native Hindu population the spinning and weaving of jute is still an important domestic industry. Gunny cloth is woven in several qualities, according to the purpose for which it is intended. That intended for bags to carry poppy or rape seed and sugar must be comparatively closely woven. A more open cloth serves for rice and seeds of a like size, while a still coarser cloth serves for covering packages. Rice, cotton, sugar, coffee, pepper and other articles of East Indian commerce are almost wholly carried in jute gunny bags, which are made and exported from Bengal.

In Dundee, the ordinary fabrics made from jute are hessians, sackings, carpets, tarpaulins, and backings for linoleum or floorcloth. The latter fabric is usually woven on wide looms. Dyed carpets, curtains and table covers are also made and are cheap and attractive in appearance, but not very durable. Millions of small, brightly-dyed prayer carpets for Moslems have been sent from Dundee to the East. Jute is also used to some extent to make theatrical wigs, &c.

CHAPTER II.

JUTE CULTIVATION.

THE jute growing region of India is situated in the province of Bengal, and principally in the north-eastern corner of it. This province of our Indian Empire is, broadly speaking, the one and only part of the world where jute is grown and, what is more singular, the only place possible. The vast delta of the Ganges and Brahmapootra, as large as Great Britain, and annually inundated in many parts by the overflowing of the rivers named, with warm humid atmosphere, produces abundant crops with little labour, which is, besides, very cheap and plentiful, the population being among the densest in the world. It may be of interest to remark that this part of India is that in which rice is most largely grown, and precisely that in which cotton is not found. The river Brahmapootra flows through the heart of the jute district, and water communications are so pervading and accessible that the crop is easily and cheaply conveyed to market.

Taking a sail up the river in one of the comfortable river steamers, we find that it cannot be compared with the Tay or the Thames. Hundreds of yards must be reckoned in miles. Perhaps no better idea of the extent of the stream and the flatness of the country can be conceived than by looking up the river and observing that the water alone marks the line of the horizon, the banks and trees actually sinking below the line of vision. As we approach the bank a dazzling mass of green verdure meets the eye, and the country for miles around is broken up with innumerable creeks and nullahs. The cultivator is glad if he can find a dry place for his hut. Such is a short description of the jute country.

Land intended for jute is generally broken up in the fall. With unwearied industry, the natives plough the land over and over again—in some instances as many as twenty times—with their primitive wooden ploughs drawn by oxen, until the soil has been thoroughly pulverized, deeply exposed to the sun and air, and richly manured. A loamy soil, or rich clay or sand, produces the finest plants. The prepared ground,

which never exceeds 20 per cent. of the cropped area in any single district, is ploughed and harrowed in the winter months, and sowing takes place in the months of April, May and June. There is what is termed an early and a late crop, depending principally on the district in which it is grown. The seed is sown broadcast, about 25 lb. per acre. There is no buying and selling of seed. Each cultivator leaves a patch of jute to ripen and furnish seed for the following year.

Low-lying lands subject to floods should always be sown with the early sorts of jute. Cultivated on a large scale, both early and late sorts of jute should be sown so that harvesting may be progressive. Jute is an exhaustive crop and should not be sown on the same ground year after year unless plenty of manure is used. It does particularly well if it follows peas or *khesari* grown specially for grazing. The following rotation of crops has been recommended: First year: (1) Jute; (2) rape or mustard. Second year: (1) Paddy, (2) peas or *khesari*. After sowing, the seed may be harrowed and rolled in.

Low lands, which receive silts every year from floods, require hardly any manure. Cowdung is the best manure for jute, and may be followed by castor oil cake. Fifty-five cwt. of cowdung or $4\frac{3}{4}$ cwt. of castor oil cake per acre, each containing 30 lb. of nitrogen, may be applied.

To ensure even distribution of the seed, the sower should go over the field twice, once from the north to south or vice versa, and a second time from east to west.

Germination takes place in three or four days if the soil is moist enough, about $1\frac{1}{2}$ in. of rain per month being sufficient for the sowing season. When the plants are about 6 in. high, a sort of rake is drawn over the land twice or thrice, at short intervals till they attain a height of nearly a foot, to loosen the earth. After this the crop is twice weeded or hand hoed, and the plants thinned at the same time. The plants should be so thinned as to leave a space of about 6 in. between the plants in the case of the variety *C. capsularis*, and 8 in. in the case of *C. olitorius*. The former branches if thinned out too much. On the other hand, if too close, the plants grow too slender and do not give a good yield of fibre. Jute is a rainy season crop, damp heat being the most favourable condition for its growth. Occasional showers, equal to about $1\frac{1}{2}$ in., at intervals of about a week, are best for the growing plants. During the growing season the temperature varies from 60° to 100° F.

Figure 1 shows fields of jute on the Brahmapootra. Just before the rainy season sets in thin and weak plants should be rooted up. Nowadays fibre is generally extracted from these rejected plants and sold as "rejected jute." The plants mature in from twelve to fifteen weeks, and sometimes grow to a height of 20 ft. The average height of well-grown plants is, however, from 10 to 12 ft., and the diameter of their butts from $\frac{1}{2}$ to $1\frac{1}{2}$ in.

Jute is cut from the beginning of July to the end of October,

FIG. 1.

usually while the plant is in flower, as the fibre is then at its best. However, it may be cut any time before the plant is dead ripe, at one of the following stages: (1) When in flower, (2) when fruits sets in, (3) when fruit is fully developed. The plant takes four weeks to get through these stages. If the plant gets dead ripe the fibre becomes coarse and a dirty reddish colour. The greatest yield of fibre is obtained when the plant is cut when the fruit is fully developed. A postponement of cutting till the crop has run to seed is responsible for the coarse fibre found on the market.

The process of cutting is clearly shown in the illustration,

fig. 2. The plants are usually cut with a sickle close to the ground. If growing in water they are pulled up. After stacking the crop for two or three days to allow time for the decay of the leaves, a method which certainly leaves the fibre stronger but allows a possibility of its discoloration, the bundles of stems are placed in tanks or pools or stagnant water. In some instances the cuttings are taken direct from the land and placed in water, still or running as may be most convenient.

FIG. 2.

The fibre is contained in the bark of the plant. Like flax and hemp, the fibre is bound around the woody matter by a kind of gum, which must first be softened by fermentation and then removed by washing. This fermentation takes place while the plants are kept under water. The bundles should be covered with straw, &c., to preserve them from the direct rays of the sun, which would make the fibre specky. Sods are used to keep the bundles under water, but this practice is to be condemned as the sods discolour the fibre. Logs of wood should be used in preference.

Fermentation sets up and softens the tissue in which the fibre is embedded, and renders the gummy matter soluble until the fibre comes away quite easily from the woody portion of the stem. The stalks should be examined periodically to test the progress of the retting operation, and when it is found that the fibre peels off easily the operation is complete and the bundles are withdrawn. The retting process usually lasts from ten to twenty days, but a late crop may take even longer. If underretted, gum remains and sticks the fibres together. Overretting makes the fibre weak and dull in colour. The

FIG. 3.

water used in retting has a considerable effect upon the quality of the fibre. If steeped in clear water, the fibre is of a light colour; while if steeped in muddy water the fibre takes a dark grey colour. Retting in running water takes longer than in stagnant water. In running water the inside bundles of a heap rot quicker than the outside bundles, producing fibre of uneven quality. The heap should therefore be broken up and the inside bundles removed when ready, the outside bundles being kept for two or three days longer in the water.

Separation or stripping of the fibre from the stem must be accomplished within a couple of days of the finishing of the retting process. Fig. 3 shows the most usual method. Stand-

ing up to his waist in the fœtid water, the *raiyat* proceeds to take as many stalks as he can grasp in his left hand, and with a flat mallet in his right to beat them flat at the end. Then he gives them a few more blows, deftly turning the bundle with the left hand meanwhile. He then breaks the bundle about 12 in. from the end—first one way and then the other. A few more blows on the water and the boon falls out, leaving the fibre clear. He now takes hold of the separated fibre with both hands and jerks the stems backwards and forwards on the surface of the water. After a few jerks the fibre is cleared off the stalks. Next, after dashing the fibre repeatedly on the water to wash it and remove impurities, and wringing as much water as possible from the handful of fibre, he passes the fibre out on to dry land to be hung out and dried in the sun. About 70 lb. of dry fibre may thus be prepared in ten hours.

Another method of stripping consists in holding the lower part of the stem in the right hand, and pulling off the fibres with the left, the fibre passing between the fore and middle fingers of the right hand in which the stem is held. A skilled stripper can extract as many as three plants at a time, passing three bunches of fibre of three different plants through three spaces made with the four fingers of the right hand, which holds the stems. Fifty pounds of fibre may be thus stripped off in a ten hours' day.

The green crop weighs about 13 tons per acre, and yields about 12 cwt. of dry fibre or about 4½ per cent. of the green weight of stems. Nearly double these weights may, however, be obtained on well-cultivated and manured land.

Fig. 4 shows the fibre hung out on a bamboo pole to dry, when it is then practically ready for the market.

This is the ordinary process familiar to everyone who knows Bengal. Primitive as it undoubtedly is, and in spite of experiments instituted by the Department of Agriculture, there has not been yet invented any mechanical process which has been able to permanently replace it, although various experiments have been tried. The poverty of the *raiyat* stands in the way of the adoption of necessarily expensive machinery, while on the other hand expert testimony confirms the contention that the old process produces a softer fibre. This quality, combined with colour, lustre, length, uniformity and cleanliness, constitutes the test of the value of the products.

Fibre retted in clear running water is strong, white and glossy, but it takes longer to ret than it does in stagnant

water. Various experiments have been made by the Department of Agriculture to ascertain if improvement in the fibre might be possible by noting the effect produced by cutting at various periods of growth, with the result that it is found that the fibre is at its best if the plant be cut when in flower.

The fibres in the raw state are of a light brown colour and are fairly fine and pliant, if somewhat harsh, and from 6 ft. to 14 ft. in length. About 14 cwt. of fibre per acre is obtained on the average, the cost of cultivation being about 28s.

At various centres, jute received from local traders is sorted,

FIG. 4.

picked and pressed for shipment. The *faria* or *palkar* is a small travelling Indian trader who goes from house to house and buys jute from the *raiyats*, or peasants. An Indian trader who buys jute, sells it at the local markets or sends it into Calcutta is called *bepai*. A *mahajan* is an Indian trader who buys jute at the markets either from *raiyats* or *fabrias*, and sends it in drums to an Indian commission agent in Calcutta for disposal. The commission agent or *aratdar* charges a commission at the rate of 1½ annas per maund, besides storage. A *koyal* is a weigher. *Ojan sarkar*, a clerk of weights; and a *jackandar*, an examiner of quality. The *palkar* and the *aratdar* frequently advance money to the *raiyats*.

Native markets, or *hats*, are scattered over the country. To these the jute is brought by boat and cart in small bundles, called paties and moras, the latter being a neatly rolled bundle of 10 lb. weight. From thence it is either made into drums (see fig. 6, which shows men making a drum) for despatch to the Calcutta markets or sent to the agencies for sorting and baling. The buyers of jute are the European firms and Marwari merchants. The latter are a rather ignoble-looking race from a district of Rajputana, and who have the same reputation as the Jew money-lender. They are exceedingly active as financiers, middlemen and traders generally. In Calcutta, they are the principal native dealers in jute. Adjacent to the Exchange, crowds of them may be seen any day in eager discussion. August to December is the busy season in the jute trade, January to July being the dull season.

At the head of an up-country jute agency is the agent, usually a Scotsman, who has a furnished bungalow all to himself. There are probably two or three other Europeans in the station, besides native servants and two or three Baboo clerks. The coolie labour is given out to contractors, who can manage the natives better than the Europeans can. The agent buys jute of the kind required when instructed by his Calcutta house.

Purchases having been effected in the interior, the jute is sent in by boat or cart to be sorted and pressed. Usually the sellers are paid on the same day, and for that purpose a large stock of silver has to be kept in the safe, for rupees only are current in the country. It is an interesting sight to see half a dozen natives squatted on their heels, laying out 5,000 rupees in piles of twenties.

Before packing, the root end, which is generally hard and woody, is usually cut off. The sorting divides itself into cuttings consisting of the woody and hard ends of the root: rejection, the lowest class of fibre, and jute proper.

The jute proper is sorted out into four qualities, or rather into three, for first and second are laid together. In reporting on the quality to the head office, the percentage of first, second and third is given, 20—30—50 or 15—25—60, as the case may be.

Fig. 5 shows the agent examining jute in the sorting shed.

Ashmara is weak jute.

Batch pat is fibre from immature plants, rejected at the time of thinning.

Bukchhal is a barky portion of fibre in the centre, due to the plant being allowed to grow after an inundation subsides.

Jute is said to be "croppy" if the top end is rough.

Ful pat is immature stuff cut before flowering. It is of good colour, but rather weak and gummy.

Jute is said to be "knotty" when full of portions of fibre which resist separation mainly on account of an insect bite or puncture on the growing plant.

"Mossy" jute is low land swamped jute with numerous adventitious roots.

Jute is called "rooty" if the gum is not removed from the root end, and the fibres consequently stick together.

Specky jute contains patches of outer bark here and there.

"Sticky" jute contains broken pieces of stick or pith.

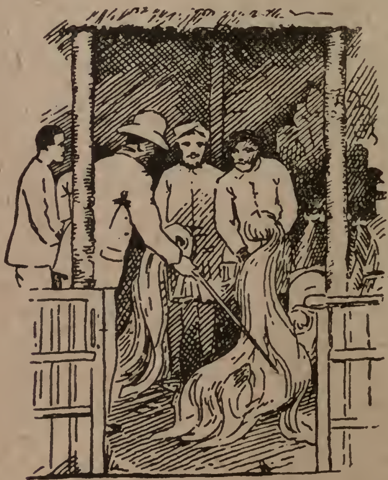


FIG. 5.

The best fibre is obtained on loamy soil. Clayey soil gives the heaviest yield, but the plants do not ret uniformly. Sandy soil produces coarse fibre.

The finer qualities of jute are produced on the high lands above the inundation level. Plants grown in low-lying swamp land give forth adventitious roots freely; consequently the root ends are only fit for paper making.

The chief cause of the deterioration of the fibre as regards strength and colour is the dishonest habit of the *farias* of sprinkling water on the fibre in order to increase its weight. Jute has been found containing as much as 30 per cent. of moisture. Sand is sometimes also added. Dry jute of commerce may contain from 8 to 10 per cent. of moisture.

After being sorted, the jute is taken to the presshouse, and made into the familiar bale, of 10 cubic ft. and 400 lb. weight, either by power or hand press. The strong iron press box is filled with the required five maunds, ready to be rolled on rails below the screw. The box, capacity 10 cubit ft., has a movable bottom, and when the bale is nearly pressed the box is removed, to be refilled while the ropes are being bound round. The coolies are paid piecework, and can turn out 15 bales an hour with ease. The screw press is worked by pulling on ropes passing over rope pulleys of large diameter. Half a dozen men pull on the ropes and sing a chorus when working together. One of their number drones a word or two of unintelligible jargon and the rest reply with "Heigh O," pulling at the same time.

FIG. 6.—Making dohls.

A baler is a buyer of loose jute who makes it up in 400 lb. bales, and sells it to shippers or local mills.

The baled jute is taken down to Calcutta in a corrugated iron warehouse built on a barge or a "flat" as it is called. One or two of these are navigated through the numerous channels in tow of a steamer for the purpose.

The north end of Calcutta along the river bank is where the great jute mart of Hautkolo is situated. There also are the jute presses and screw houses, conveniently adjacent to the river and the Port Trust Railway. Immense quantities of jute are imported and exported here every day. Fig. 7 gives a view of Kidderpore dock, and shows the bales being shipped. Along the shore is a perfect mass of huge country boats landing and shipping drums, others taking in bales for

loading big four-masters down the river where jute clippers lie. Steamers, as a rule, take in their cargo at the dock, where the railway runs alongside.

Bales are frequently carried on the heads of three natives.

A shipper is an exporter of baled jute.

FIG. 7.—Shipping jute.

A broker is an agent employed to make bargains or contracts between buyers and sellers, for which he is paid 1 per cent. brokerage.

An under-broker is a broker who cannot approach the buyer, but does business through a broker, who allows him one-fourth of the brokerage.

CHAPTER III.

QUALITIES OF JUTE.

In the Calcutta market, a series of commercial staples are recognized as based on the districts whence they are drawn, their values bearing a fairly constant relation to each other. These classes in order of quality are:—

(1) Uttariya, or northern jute, coming from Rangpur, Goalpara, Bogra and the districts north of Sirajganj. These jutes are unequalled for length, colour and fineness.

(2) Deswal or Sirajganj jute is valued on account of its softness, bright colour, fineness and strength, being superior in the latter characteristic to Uttariya jute.

(3) Desi jute, coming from Hooghly, Bardwan, Jessori and the twenty-four Parganas.

(4) Deora jute, which is produced in Faridpur and Bukarganj, and yields a coarse dark-coloured fibre, used principally for rope-making.

(5) Naraingunja jute from Decca, a strong, soft and long fibre of inferior colour.

(6) Bhatail jute from Decca, which is good rope-making fibre, being coarse and strong.

(7) Bakrabadi jute, from Decca, soft, and fine in colour.

(8) Karimganji jute, from the Mymensing district, a long, strong staple of good colour.

(9) Mirganji jute, the produce of Rangpur, which is harsh and woody from over-ripeness.

(10) Jangipuri jute, from Patna, a weak and foxy-coloured fibre of very inferior quality. In the European markets these distinctions do not carry much weight, traders' marks and classes being the accepted standards of quality and condition.

The standard quality of the baled jute market is what is known as the M Group or "Cracks", which belong to the jute of the Serajgung Division. They are made up in equal proportions of Nos. 2 and 3 qualities, packed separately, the No. 2 giving 40 per cent. of hessian warp and the No. 3, 70 to 75 per cent. of sacking warp; not without a large percentage of hessian weft in the latter. The M Group forms

the basis of all advices regarding market prices. As, for instance, if the quotation for jute from Hamburg comes at £26 10s., it is to be understood that it is the value per ton of M quality of jute at that port.

Next to the standard M, which is connected with the name of its originator, the late Mr. Mangos, the Decca group is the most important quality in which business is done. It is always in good demand. It is made of Naraingung quality assorted into 2's and 3's, similar to the standard M. The market value of this jute is often a little higher than M, say 8 annas to 1 rupee per bale.

The CDM grade is picked out of the medium and common jute coming from North Bengal and from the residue of the higher marks. It is largely used for sacking-purposes.

The "Hearts" are low grade jute used in the manufacture of gunny bags.

There are some marks of fine and exceptionally good quality in which only a limited business is done, principally with Dundee and France.

Another quality is Daisee jute (*C. olit.*) which is free from bad roots. It is exported in three principal numbers, 1's, 2's and 3's. The general standard is in equal percentages of 1's and 3's, such as 10 per cent. 1's, 80 per cent. 2's, and 10 per cent. of 3's.

The four kinds of jute chiefly imported into this country are Serajgunge, Naraingunge, Daisee and Dowrah.

Serajgunge has a soft fibre, of a whitish or dull grey colour with a bluish tinge, and without the red root or tips found on some jute. The roots of this sort of jute are sometimes of a somewhat dark shade. The best qualities are used for high-class yarns, both warp and weft, the lower qualities being used for medium and common warps and wefts. This jute is more easily bleached than other varieties. It is grown upon that tract of land watered by the new Brahmapootra river or by the Jamuna river.

Naraingunge jute is grown on the tracts of lands supplied with water from the old Brahmapootra river. The colour of this jute is very good, as the water is unusually clean. Most parts of this tract are liable to flooding, hence the rooty and mossy nature of the fibre. The high lands of this tract yield fibre of exceptionally good quality. Naraingunge fibre is strong and pliant, but of inferior quality to Serajgunge. The colour ranges from a bright cream colour to a dark red. Like Serajgunge, about 30 per cent. is "hessian," the best

quality fibre being used in the production of superior warps and wefts and into common wefts. Naraingunge and Chandpur are the principal markets.

Uttarya, or northern jute, is grown in the tract of high land watered by the tributaries of the Brahmapootra. Jute grown here is principally steeped and washed in dams, and as the water is used over and over again the colour of the jute is inferior. About 30 per cent. of this jute is likewise "hessian." The lowest class of jute is Dowrah, which is dark or dull grey in colour with a slight tinge of green. The fibre is harsh, dirty and brittle, and can only be used in a mixture for sacking yarns, or mixed sparingly for heavy common wefts. A peculiarity about Dowrah jute is that when put into yarns, the harder the twist of the latter the weaker it becomes. Consequently it is not at all suitable for warp yarn. Dowrah jute is grown on land which is swamped with muddy water by the branches of the Ganges. The muddy water gives the fibre a grey colour.

Daisee jute is grown on the high lands round Calcutta. Jute from this district is steeped in ditch water or in local rivers which in flood are very muddy. Jute from this tract is consequently dark in colour, varying from light pink to a dull slate, and is only of medium strength. It is always used as a mixture in hessian and common weft yarns, and sometimes also in small quantities in warp yarns in order to reduce their cost.

The bales of jute, as brought into the Calcutta bazaar, are divided into the following qualities:—

1's,	containing	80 to 90	per cent.	of hessian	warp.
2's	,,	40	,,	,,	,,
3's	,,	60	per cent.	of sacking	warp.
4's	,,	20	,,	,,	,,

Rejections, containing all weft.

The standard quality of the loose jute market is called 50/50, i.e., half 2's and 3's.

The jute fibre trade of Calcutta is almost exclusively in the hands of Europeans. The fibre is sorted and then pressed into bales for export. Each sort has its own special mark, and in selling a lot the shipper usually guarantees a certain quantity of each sort, such as 5 per cent. of first numbers, 50 per cent. of second numbers, and 45 per cent. of third numbers. Special qualities are sold separately.

The greatest defects found in the fibre as imported into

Scotland are heart and surface damage, and the presence of roots and runners. Heart damage is caused by heating in the centre of the bale, owing to the fibre having been pressed in a damp condition. Surface damage is done in transit by exterior dampness, usually due to the ship's hold not being properly ventilated. Runners are fibre produced from stems of the plant which have fallen down and grown along the grounds and are consequently of very inferior quality.

A coarse root end is a common defect, and if not removed reduces the spinning quality of the fibre very materially.

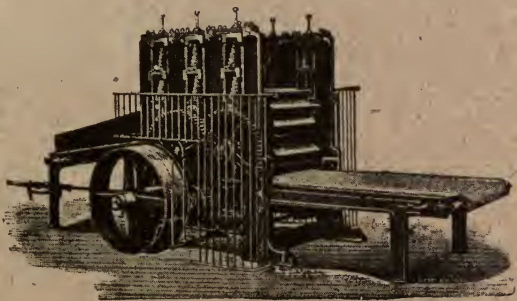
A good deal of jute is prepared in Calcutta by the snipping process instead of by cutting off the roots. The snipping or knifing machine consists of a toothed cylinder, running at a speed of about 200 revolutions per minute. In the rear of the cylinder, and horizontal with its centre, are a pair of fluted rollers, driven independently of the toothed cylinder by a separate belt. By a suitable arrangement of three pulleys, one of them being a loose one, and a long handle for shifting the belt from one to the other, the feed rollers may be stopped or driven at will in either direction. In this way the operative is enabled to spread a "strick" of fibre upon the endless feed sheet, introduce the bad end between the feed rollers as far as required, retain it there until the toothed cylinder has acted upon it sufficiently long, and then withdraw it again without danger. The hard and flat ends are cut away and thrown down below the cylinder and may be sold for spinning into coarse sacking yarns.

CHAPTER IV.

MANUFACTURE OF JUTE.

SOFTENING, BATCHING, HACKLING.

IN the jute mill the manufacture commences with the operation of opening, batching and softening. The jute opener, fig. 8, serves to render the "heads" or sticks of jute, as taken from the 400 lb. bale, which has been pressed into a volume of 10 cubic ft., soft, pliable, and easily handled by the batchers. As will be seen, the machine consists of



Jute Opener.
Ballen-Oeffner
Кипомяльная Машина.

FIG. 8.

three pairs of coarsely fluted or knobbed rollers, pressed together by very strong spiral springs. The rollers make about eight revolutions per minute, and the raw material is fed in upon a feed sheet and delivered at the other end upon a delivery lattice. Such a machine occupies floor space about 9 ft. by 6 ft.

The operation of batching jute consists in the application of a mixture of oil and water with the object of softening and lubricating the fibre, so that it may pass more easily through the subsequent processes of carding, drawing and spinning, without lapping upon the rollers, as it otherwise would have a tendency to do.

The batching liquid consists of about 85 per cent. of water and 15 per cent. of oil and soap, some of the mixtures used being made after the following recipes:—

(*a*) Whale oil 2½ gallons, mineral oil 2 gallons, and seal oil 2½ gallons, to 40 gallons of water.

(*b*) One gallon of seal oil, 5 gallons of sperm oil, and 10 lb. of soap, to 40 gallons of water.

(*c*) One and a half gallons of mineral oil, 2 gallons of sperm oil, 2 gallons of seal oil, and 2½ lb. of soft soap, in 30 gallons of water.

For common sacking wefts, a cheap batching mixture composed of 10 per cent. of Pennsylvania oil and 90 per cent. of water will serve the purpose.

When the jute is intended for bleaching, alkali in the form of soap, caustic soda or dilute ammonium hydrate may be used to saponify the batching mixture, in quantities in proportion to the quantity of mineral oil used. If soap be used, from 3 to 5 per cent. will be required per gallon of oil. If caustic soda is used, about 1 per cent. of this substance per gallon of oil used will be sufficient. When fish oil is used a smaller percentage of oil is required than when mineral oil is used.

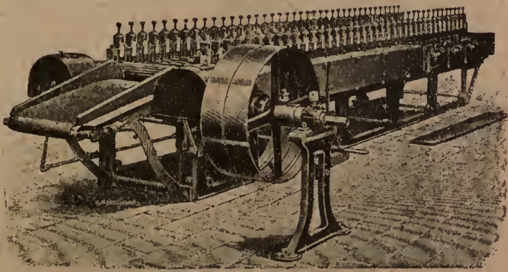
The batching liquid is best prepared by first measuring the oil, &c., into a tank and then adding the water in the proportion of 3:1. The mixture is then boiled, when the other portion of water is added and the whole again brought to the boil and kept heated. This liquor is applied to the fibre at the rate of about 10 gallans to each 400 lb. bale of jute. In hot weather, a rather larger quantity may be applied, as the water will evaporate during the preparation of the fibre for spinning.

The batching liquid may be applied as the fibre is delivered from the opener. In hand batching the batchers piece out or "strick up" the heads into handfuls weighing about 2 lb. each and place these stricks layer upon layer into a stall with the root ends at the back.

In this way the body of the strick can receive the proper proportion of oil and water, while the root ends may be given an extra quantity of water to help to soften them down. The oil is first applied from a hand pan, and then the water from a fine rose head attached to an indiarubber water pipe. The operation is repeated with every layer until the stall is almost one-third full, when the layers are stamped and tramped down. Additional layers of fibres are then added and batched

and again tramped down, the top layer of all getting an extra dose of liquid as it is more subject to evaporation. In "hand batching" the oil must in all cases first be applied and then the water if good results are to be obtained. The batched jute should be allowed to remain in the stalls for twenty-four hours, so that the oil may percolate through and be absorbed by the fibre before it is removed to the card room.

Machine batching is, however, the method now nearly universally adopted, being superior to the old style of hand batching in everything, except that an extra quantity of oil cannot be applied to the hard root ends. In machine batching, the oil and water are applied to the fibre as the stricks pass through the rollers of the softener (fig. 9). The water and oil are generally supplied by separate pipes from overhead cisterns, the water being applied first and then the oil, in



Jute Softener.
Jute-Quetsch-Maschine.
Джутомялная [illegible]

FIG. 9.

contradistinction to the method employed in hand batching. The supply of water is regulated by a valve actuated by levers and a connecting rod from one of the upper softening rollers. When a large strick passes, the valve is opened wider, and vice versa. The supply of oil is regulated in a like manner by another rod a little further on.

The jute softener, fig. 9, consists of from 31 to 100 pairs of spirally fluted rollers, pressed together by spiral springs. The production of such a machine is about 10 tons per 10 hours day, to which 3 per cent. of oil and 15 per cent. of water is added. The floor space required by a softener of 47 pairs of rollers is about 28 ft. by 5 ft. Leaving the softener, the stricks of jute are laid upon a barrow or

wagon, which when filled is put upon one side and allowed to stand for twenty-four hours for a reason already explained.

As the root end of the plant ripens first, this end usually produces fibre of inferior quality to that extracted from the middle portion of the stem. Consequently if full advantage is to be taken of the good quality of the middle portion, the inferior portions must be removed. The old-fashioned way of doing this is by cutting or "snipping." When a fine quality yarn is required, the root end of the fibre may be cut off upon a steel blade about 3 ft. long and 6 in. broad, fixed in a wooden frame, the whole arrangement being termed a jute snipper, or a cutter as shown in fig. 10 may be used.

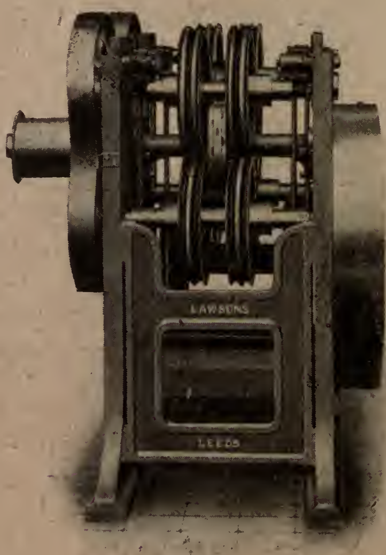


FIG. 10.

A newer method consists in the use of what is termed a jute end comb. Such a machine is shown in detail in figs. 11, 12, 13 and 14. Fig. 11 is a side elevation; fig. 12 a view looking in the direction of the arrow; fig. 13 is a plan of the same, while fig. 14 is an enlarged part sectional view showing how the fibre is held as it travels through the machine. In this machine the root ends are hackled, combed, carded and cleaned by a pinned cylinder (3). As will be seen, the fibre is carried across the face of the carding cylinder by

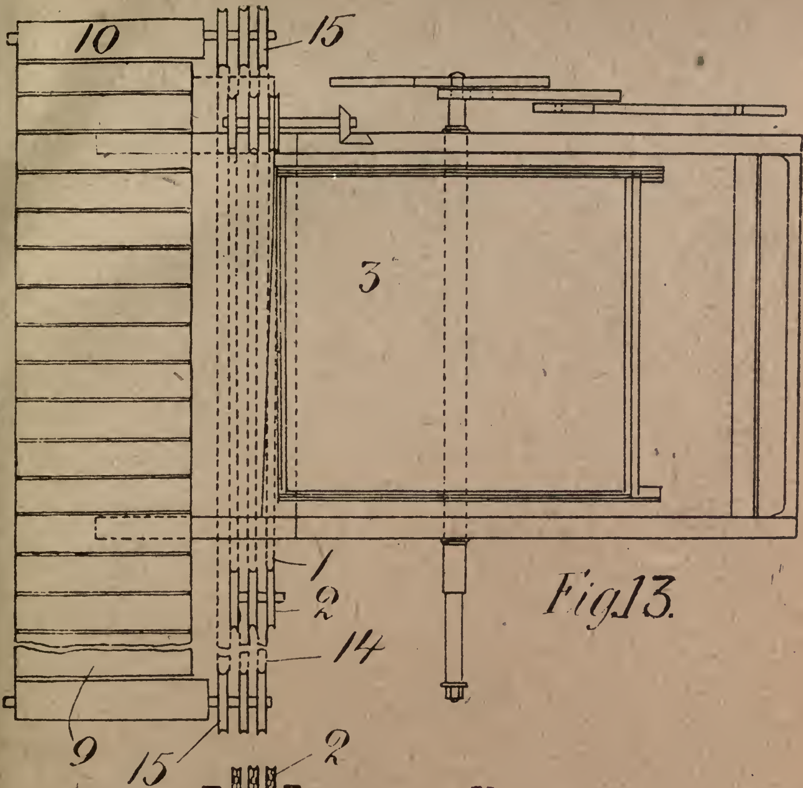


Fig.13.

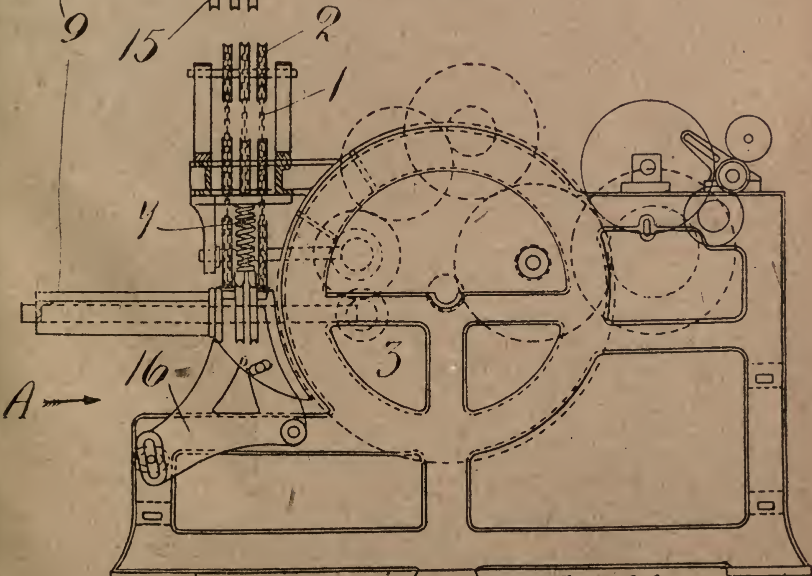


Fig.11.

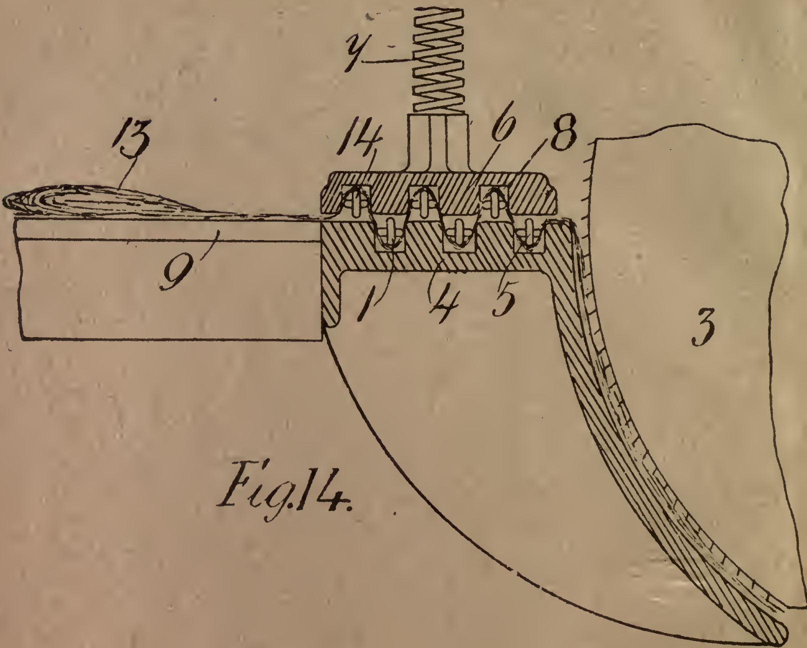


Fig. 14.

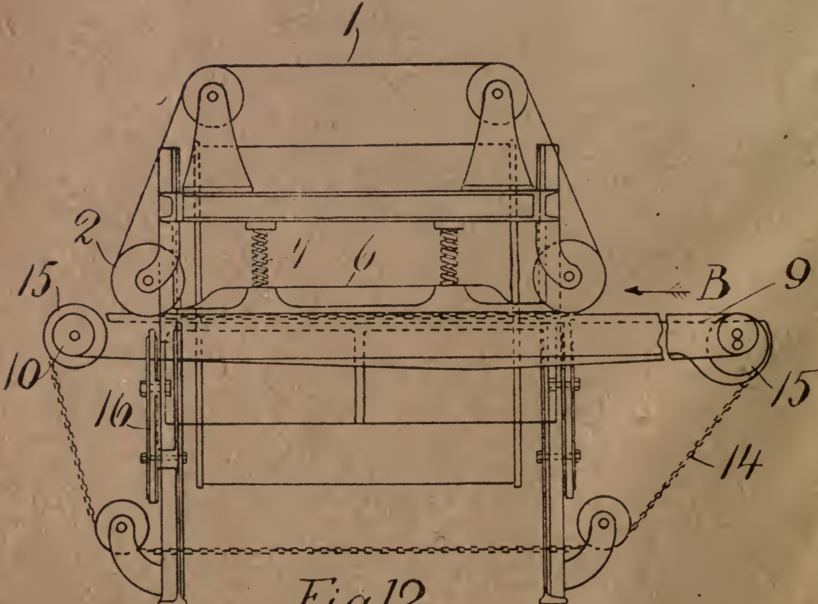


Fig. 12.

means of carrying chains or ropes (1) which are carried by a series of guide pulleys (2). Beneath these chains or ropes (1) and at the feed side of the machine is fixed a grooved shell or plate (4), in the groves (5) of which the chains (1) can traverse.

A similar series of chains or ropes (14) are also arranged to pass over the pulleys (15), the arrangement of the two sets of chains being such that the upper set of chains (1) pass over the front of the cylinder in one plane while the lower set of chains pass in a plane above, the planes being almost radial to the cylinder. A tension device in the form of adjustable pulley brackets are provided for the chains or ropes (1 and 14). A spring pressure plate (6) is arranged immediately above the grooved shell (4), the downward pressure being given by springs (7), its function being to keep the chains in their grooves and thus assist in holding the fibre. This plate is also provided with longitudinal grooves (8). The shell (4) is made adjustable for setting by means of brackets (16), which clamp it to the framework of the machine. (9) is a feeding table with moving cloth, which is driven by the roller (10), the surface speed of the cloth being equal to that of the chains. The chains and the feed table both move in the direction of the arrow B, figs. 12 and 13. When the machine is in operation, a strike (13, fig. 14) of the raw material is laid crosswise over the feed sheet (9) and the chains, hanging down over the chains (14). The strike is fed (14), at the feed end of the table, the end to be combed carried into the machine by the feeding cloth (9) and the chains (14) until it is caught between the chains (1 and 14) and the end of the material thus being brought into contact with the pins on the cylinder (3) is cleaned and refined as it is moved across its face. The strike is then delivered at the other end of the feed cloth by the delivery rollers at the front.

Orr's Patent Root Opener for opening roots and cuttings consists of four swifts or cylinders all revolving in the same direction. These cylinders are studded with strong steel pins which intersect stationary pins fixed in breast-plates. The rubbing action opens and cleans the roots, and the dirt and sand fall out through the grating underneath the cylinders. The cuttings or roots are fed evenly on to the feed-table and are carried up to a pair of fluted rollers which pass them down into the hopper and then into the machine. The root-opener should be placed in such a position to deliver directly on to the feed-table of the softener, thus saving labour, and

this arrangement insures an even feed for the softener, which in turn is most important for uniform batching.

The finest and best quality jute yarns are produced on the Continent and by one or two Scotch spinners from the central portion or "middles" of the fibre, from which the inferior ends have been removed by cutting, spun as long line and not carded as is the bulk of the raw material. This reduction of the fibre in length also facilitates the hackling of the middles by machine, which are seldom, if ever, made for a greater length of fibre than 6 ft. Such a machine is called a "giant" machine, for the same machine as used for flax seldom, if ever, has a lift of over 24 in., say for fibre 36 in. long at most. The cutter, fig. 10, which may be conveniently used for cutting up the "strikes" as they come from the softening machine, into convenient lengths, consists of four pairs of grooved and heavily loaded rollers, each two pairs being acted upon and pressed together by a weight, acting through compound levers and links and exerting a pressure of more than one ton, distributed between two pairs of holding rollers. These rollers are placed on either side of a quickly revolving cutter, so that their point of intersection lies in the same vertical plane as the periphery of the cutter, from which they are distant about 1 in. on either side. The cutter blade consists of three steel rings, each about $\frac{1}{4}$ in. thick, placed side by side and keyed upon a shaft supported by the gables of the machine and carrying the driving pulley keyed upon one end. From the other end of this shaft a retarded train of gearing drives the bottom holding rollers, which are of cast iron, 14 in. in diameter and 2 in. in face, with vertical and circumferential grooves or flutes of 1 in. pitch. The bottom roller has two flutes and the top roller only one, with two grooves. The top or pressing rollers are free to move up and down in slides in the gables and are driven by friction. Upon the rim of each of the rings composing the cutter blade are projecting teeth of diamond-shaped section, placed at distances of about 3 in. apart. It is most important that these teeth should be of the proper shape and bluntness to cut through the fibre without shearing the ends quite square, which would seriously affect the combining and spinning properties of the fibre. The cutter makes about 1,000 revolutions per minute and the holding rollers two or three revolutions in the same time.

The machine being started and having attained full speed, the cutter boy takes a strick of fibre firmly with both hands

and allows it to pass in between the holding rollers with the part to be cut opposite to the cutting blade. He holds the piece firmly and bears down upon the bottom rollers, his hands passing outside them until the cutting is complete, when he withdraws the cut pieces. A boy can thus cut about 4 cwt. per day.

For hackling the stricks must be pieced out or divided up into handfuls of suitable size for the hand hackler or for the hackling machine holder. If the jute is nearly 6 ft. long, these pieces may run 2 or 3 per lb. Hand dressing or hand hackling is the process of subdividing or splitting up the fibres by pulling them in handfuls through tools or hackles, instead of subjecting them to the action of the hackling machine. In hand-dressing the handful of fibre is thoroughly hackled up to the hand upon a coarse hemp keg and rougher's hackle and then upon a finer hackle called a "ten." When being pulled through these tools the piece should be well spread out and supported by and passed through the left hand close up against the front row of pins of the hackle. The proper use of the left hand as a support is a very important point in obtaining yield through preventing the breaking of long fibres. In the use of the hand hackle it must be remembered that it is only the points of the pins which cut up and split up the fibre into finer filaments, hence the piece should be kept well on the surface of the hackle, the proper and equal cutting of both faces of the piece being insured by turning it in the hand and giving a like number of "blows" to either side. When thoroughly hackled, a lap is put upon the piece and it is built with others into a compact bunch, which is tied up with bands and stored until required.

For machine hackling the pieced out fibre is placed upon tables at the coarse or filling ends of the hackling machine, as seen in fig. 15, the root ends being turned from the boy or filler, who takes two pieces at a time and leaving the root ends projecting about 36 in., places them level and flat, one piece on either side of the central screw of the holder, and spreads them well out upon the bottom plate of the holder.

The holders are placed one at a time in the channel of the machine, when it is approaching its highest point, and are then shifted automatically forward, step by step, every time the head arises, over the hackles, gradually increasing in fineness, until they are delivered at the fine end, where the holder is placed in a stand, another holder being placed in a corresponding position about $2\frac{1}{2}$ in. distant. The hackled

end of the fibre is tightened into the empty holder and the other being removed, the new holder, with the top end of the fibre now projecting downwards, is placed in the channel of the other machine, where it undergoes the same process and is delivered finished at the fine end. The boys remove the finished pieces from the holders, and crossing each piece in a tipplebox or upon a stool, form a compact bundle or tipple, the ends of which may be tied or "tippled up" before the bundle is removed to the preparing room.

The machine boys' work is heavy, but may be considerably lightened, and the yield from the machine improved at the same time by the use of either anti-friction washers or anti-friction nuts for the holders. The former arrangement consists of a pair of circular steel washers grooved to hold a ring of steel balls. The uppermost washer is slightly tapered, and is held in place by a cover which is riveted to the holder plate. The anti-friction nut is constructed on the same principle as the washer, the grooved steel washer and ring of steel balls being, however, in this case contained in the nut itself, rendering any work upon the holder unnecessary. By the use of this washer or nut the usual friction between nut and holder is so much reduced that, with the same effort, the holder may be tightened more than three times as tight, leaving no excuse at all for badly tightened or slack holders, which let the fibre slip and diminish the yield of dressed line very materially.

An arrangement, so far but little known to the jute trade, is the automatic arrangement for screwing and turning the fibre in the holders of the hackling machine, one boy only being required to attend each pair of machines, instead of four boys as formerly. Part of this machine is seen in fig. 15, p. 31. In the ordinary way, when four boys are required per pair of machines, two of them, called the "fillers," place the pieces of raw material in the holders and insert the latter in the channel of the machine. At the same time they remove the handful of finished fibre from the holders issuing from the fine end of the finishing machine. The two boys at the other end of the machine are called "changers," their duty being to change the holder from one machine to the other and to change the pieces end about.

A slight modification of the holder is the starting point of the automatic machine. The holder screw, instead of being rather nearer to the lower edge of the holder plates, as usual, is placed exactly in the centre, so that the holder may be used

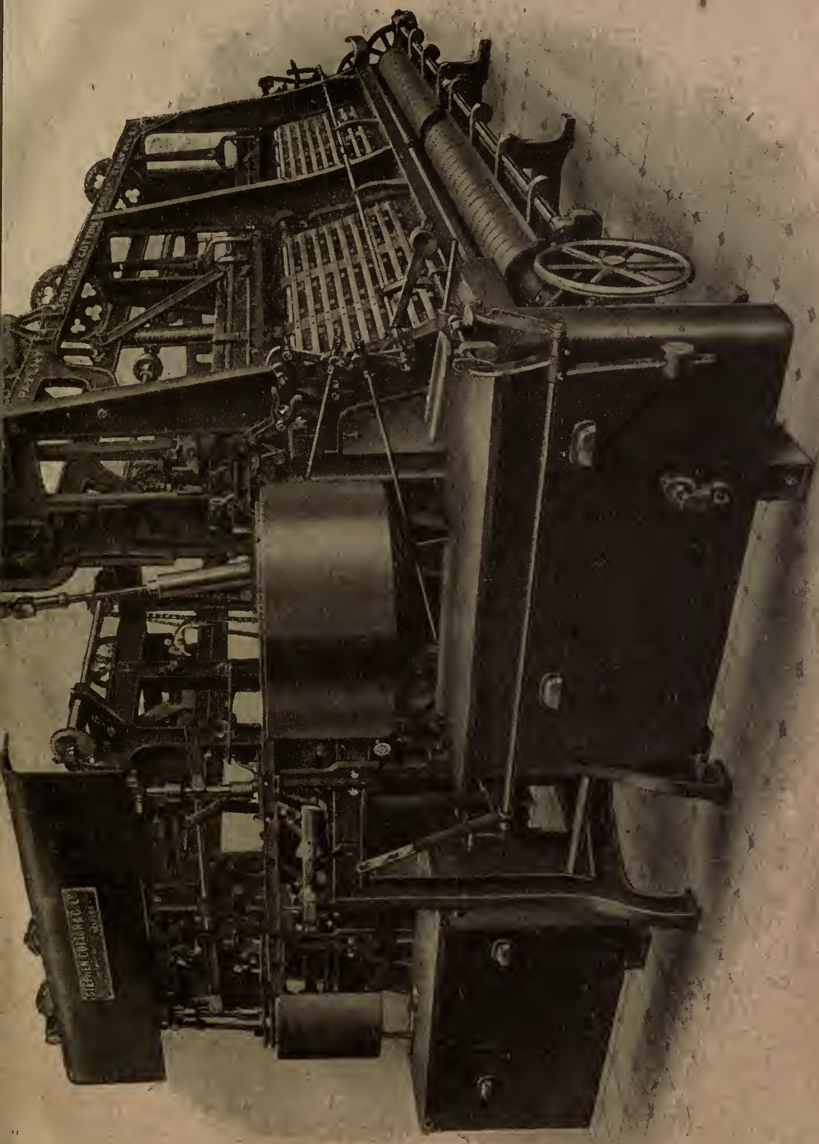


FIG. 15.

with either of its longitudinal edges downwards. The holder nut also is attached to the cover in such a way that when the nut is unscrewed the cover is raised or separated from the bottom plate of the holder.

The machines are placed parallel to each other and are coupled together, one belt driving the pair. The holder from the finishing end of the second machine is automatically delivered on to a cross channel and unscrewed, permitting the hackled pieces to be removed. The holder is then passed on, and the cover is automatically raised in order that the boy may fill the holder with fresh pieces. When this has been done, the holder passes on under the screwing spindle and, after being tightened up, is automatically raised and placed in the channel of the first machine. The changing end is completely automatic and is similar to the filling end, the chief difference being that the holders are unscrewed and screwed by the same spindle. While the holder is unscrewed the pieces are drawn through it a short distance, corresponding with the shift under the old system. The pressure under which the holders are screwed is easily regulated, and, once adjusted, all the holders are equally tightened. The arrangement can be applied to existing machines without structural alterations. The chief advantage is a saving in wages, since one boy can attend to one pair of machines, doing with ease what under the old system was heavy work for four boys. Better yield is obtained owing to the absence of slack holders. The fibre is less tossed and the boy has more time to spread the pieces in the holder, which is of the utmost importance to secure well-cut fibre.

In machine hackling the machine should be constructed and set in such a way that the pins enter the piece directly and as near the nip of the holder as possible, minimizing to the greatest extent the length of "shift" required in changing the pieces in the holder for the purpose of hackling the top or crop end.

With the best existing machines, the minimum shift possible is about $(n \times 2) + \frac{1}{2}$ inch, n being the distance from the nip of the holder at which the pins strike the fibre.

If all the fibres are firmly held by the holder only those which are cut away and broken will go into the tow. The fibres, unless excessively weak, will not be broken if presented to a sufficiently coarse hackle in a perfectly straight condition. Beginning with a coarse hackle the fibre must be gradually operated upon by finer and finer hackles.

The following is a suitable gradation for a hackling machine with 12-in. holders for jute line:—

Pins per inch ...	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	4	6
No. of wire b.w.g.	8	10	12	14	15	15	16	17	18

Hackling machines may be broadly divided into two classes, i.e., brush and doffer and stripping-rod or stripping-bar machines. The difference between a brush and doffer and a stripping-rod or bar machine lies in the way in which the tow is removed from the hackles. In the former the tow is removed, as already described, by a revolving brush, while in the stripping-rod machine the hackles are cleared of tow by means of stripping-rods or wooden laths, corresponding in number with the bars in the sheet and 3 to 4 ft. long, about 2 in. broad, and $\frac{1}{4}$ inch thick. The wood is shod with metal ends, or "stripper cocks," which work in slots and are carried round with the sheet. As the sheet passes round the bottom roller, the stripper rods shoot out by gravity to the lower extremities of their slots as they are carried round towards the under side of the roller, falling back again as they approach the top. When falling outwards the rod passes close to the pins of the hackle, loosening the tow from them, the tow being then received upon a "tow catcher," which deposits it in the tow box every time the head rises. The stripping-bar machine has a sheet of metal bars of the same pitch as the hackle bars, but exceeding them in number. This stripping sheet runs round the outside of the hackle sheet, its bars occupying the spaces between the hackles, its extra length enabling it to be drawn outwards from them at a given point by means of a tension roller, thus clearing away the tow.

Tipples are compact bundles of handfuls of machine-hackled fibre, formed by crossing the pieces one over the other as they are removed from the holder of the hackling machine. It is so called because the four ends are tippled up. "Tippling up" is the bringing together of the ragged ends of the pieces composing the tipple and the lapping around them, in the form of a top knot, of some of the loose fibres drawn out for that purpose.

The fibre having been suitably prepared by hackling and the tipples removed to the preparing room or line store, the next step towards the production of jute line yarn consists in the formation of a continuous fibrous ribbon, technically known as sliver, from the disjointed fibres. This may be accom-

plished after the old fashion by hand upon a spread board or spreader, such as is shown in fig. 16.

This spread-board consists of a table 3 to 5 ft. broad and, say, 6 ft. long, over the surface of which four or six endless leathers are carried by means of rollers at either end. Upon these leathers the handfuls of fibre are thrown or spread lengthwise, one piece overlapping the end of another in such a way that a continuous ribbon is formed, which being delivered by the leathers through conductors to the feed rollers, and thence to the gills, is carried forward to the drawing or drafting rollers. The gills are carried upon fallers. The fallers are thin but deep bars, extending parallel with the feed rollers, and resting at the ends upon top and bottom slides, the ends themselves being formed to work in the

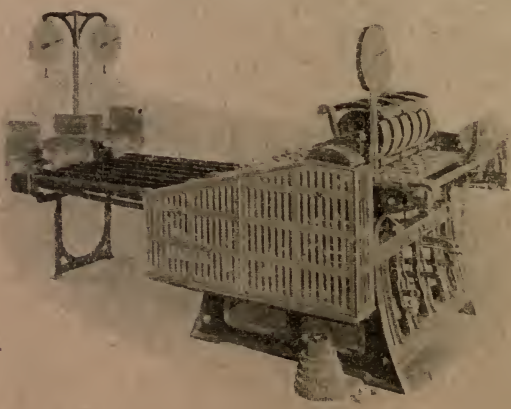


FIG 16.

square threads of revolving screws, by means of which those upon the top slide are moved forwards and those on the lower slide are carried in the opposite direction. The bottom screws are coarser since they are only employed to conduct the fallers back again to the feed rollers, where they are raised by a tappet into the top screw and on to the top slide, where they conduct the fibre forward to the boss roller, and are then knocked down by another tappet into the bottom screw and on to the bottom slide, there to repeat the motion. Springs or weighted guides are provided at either end of the slides to regulate the rise and fall of the bars front and back. The back end of the top slide is shaped to work in a groove in the faller end to assist in keeping them in correct position.

The guard or guide at the front works in the same groove with a like object. In consequence of the wear and tear of the fallers and slides, entailed by the fall of the former, reception levers are provided and actuated from the screw, receiving the faller as it leaves the top slide and depositing it upon the lower.

When the fallers rise close to the feed rollers the pins of the gill penetrate the fibre, which is conducted forward by them to the boss or drawing roller. This roller has a surface speed ten to thirty times that of the feed or retaining rollers. The fibre is consequently drawn through the gills, further split up and parallelized. When being drawn from the gill the fibre passes through a conductor slightly narrower than the gill, so that a sliver of uniform width is formed. Each of the slivers issuing from the boss or drawing roller is passed through a separate slot in a doubling plate, and then all out again through another slot, the tension being maintained by means of a pair of delivery rollers having a slight lead which, drawing the sliver through a conductor, deposit it in a can.

In the spread board the slides are inclined from back to front to give the necessary height of table at the back.

The gills consist of rows of steel pins set in a brass stock or driven through the faller bar itself. If in a brass stock the latter is riveted to the faller bar. The function of the gills is to govern the delivery of fibre to the drawing roller and prevent them from being "gulped" or drawn away irregularly, forming thick and thin places in the sliver. They "pin" the fibre properly when on rising they penetrate right through it, so that no fibre rides over the top of the pins. Sometimes a small iron rod is inserted between the delivery point of the feed rollers and the fallers as an aid to good pinning. Usually it is merely necessary to keep the sliver tight in order that the gill may penetrate it. To keep the sliver tight, the faller is given a small "lead" or greater surface speed than that of the feed roller. The "lead of the faller" is usually from 2 to 5 per cent.

The fibres are drawn out by means of the scored boss roller acting in conjunction with a leather-covered metal pressings roller of comparatively large diameter. Pressure is applied to the axle of the latter by means of simple or compound levers placed underneath and fulcrumed in the framing of the machine. The levers draw the pressing rollers downwards by means of a rod, known as a "spring wire," with hanger on the upper end, which either encircles the ends of the roller

axle when the bosses are single or that portion of the arbor between the bosses when the latter work in pairs. The pressure upon each boss may be up to, say, 1,500 lb. depending upon the breadth of the conductor.

The way to calculate the leverage or pressure exerted upon the rollers is as follows: Suppose that a simple lever be employed, the weight used being 40 lb. and placed at a distance of 60 in. from the fulcrum or working centre of the lever. The spring wire is attached at a point 2 in. from the fulcrum. The pressure upon the bosses, as usually calculated and neglecting the weight of the lever itself and the angle of the spring wire is then $\frac{40 \times 60}{2} = 1{,}200$ lb.

With two levers, one with a weight of 12 lb. attached at a point 24 in. from its fulcrum and compounded with another by means of a link pivoted at a point 3 in. from the fulcrum of the first and 30 in. from the fulcrum of the second, the spring wire being attached at a point 2 in. from the fulcrum of the latter, the total pressure upon the roller, calculated as before, is now $\frac{12 \times 24 \times 30}{3 \times 2} = 1{,}440$ lb.

In practice, the weight of the levers themselves is usually neglected, but it should not be so, since their weight increases the actual pressure considerably. With compound levers the effect would be the same as another weight equal to that of the lever acting upon the upper lever at a point corresponding to the centre of gravity of the system, or the point from which the levers, if detached, might be suspended in equilibrium. The spring wire is always inclined at an angle of 30° to the vertical, since its point of attachment with the levers is not directly under the rollers, nor is the point of contact of the rollers exactly on the top, but a few degrees forward from the centre.

"Sleeking rollers" are a pair of plain rollers about 2 in. in diameter placed parallel to and close in front of the boss or drawing roller and its pressings. They are given a slight lead on the drawing rollers, and assist somewhat in drawing as well as preventing the fibre from lapping upon the leather pressing roller.

A crush is caused when a lump or insufficient drawing power causes the pressing roller to stop turning. When this occurs, the sliver, which is being brought forward by the gill, is not

drawn away, but accumulates behind the conductor, often twisting a fast conductor and smashing the gills before it is noticed.

As hinted, the front conductors are either fast or loose. The back conductors are always fast and are in two pieces, fixed at the required distance apart by means of screws. The fast front conductor is either in one or two pieces and attached to the conductor bar running behind the pressing rollers. The loose conductor either lies upon the bar or has a projecting hook behind, which hangs upon the rod corresponding to the conductor bar. The front portion of the conductor is circled to half surround the roller, the toe projecting right into the nip of the rollers. The top face of the conductor is hollowed out to correspond with the curve of the largest pressing roller to be worked. The conductor and rollers are placed exactly opposite the rows of gills from which the sliver is to be drawn. The loose conductors have lugs between which the bosses of the pressing rollers work, the conductors being thus kept in their proper positions.

The calendar rolls are heavy metal bosses which lie upon the delivery bosses and by their dead weight provide sufficient pressure to render the slight lead of the delivery roller over the drawing roller effective in keeping the slivers tight upon the sliver or doubling plate. It will generally be found that the second sliver from the delivery roller runs slackest upon the doubling plate, the reason being that it is this sliver which, when all are brought together, lies against the surface of the delivery roller and has its proper surface speed. The others lie further from the centre of the roller, and consequently have a higher surface speed, the effective diameter of the delivery roller being, as far as the outside sliver is concerned, its own diameter plus twice the thickness of the combined sliver.

Rubbers are used to prevent loose fibres from lapping round any of the revolving rollers between which they pass. When placed underneath the roller they are pressed upwards by means of springs or levers, when on top they generally lie pressed by their own weight. The body of the rubber is of wood or metal, or both. The rubbing surface is covered with one or two layers of felt or thick flannel, which is glued on.

Cans of sliver of uniform weight for a given length are obtained from the spreader by working upon what is known as the "clock system." Under this system the spreader can be compelled to put a given weight into a given length

of sliver, the regularity with which she does so, however, depending upon her application and diligence.

The necessary mechanism consists of a Salter's spring-balance with a dial graduated up to, say, 40 lb. and a dish to hold a like weight of fibre, both being placed convenient to the hand of the spreader. Upon the delivery roller of the spread-board is a worm gearing with a changeable worm pinion upon a short shaft which lies underneath the sliver plate. Upon the other end of this short shaft is a bevel pinion driving into another upon a vertical spindle, which, by means of more bevel gearing, gives motion to the hand of a dial, seen in the illustration fig. 16, and graduated in a similar manner to that upon the Salter's balance. If 40 lb. of fibre are placed in the tray when the hands of the geared dial points to 40, both dials will be alike. The spread-board being started, the aim of the spreader must be to keep them alike by spreading the fibre regularly, taking it from the scale, and reducing the indicated weight as fast as the geared hand moves round backwards from 40 to 0. The 40 lb. of fibre may thus be formed into any length of sliver, as the weight of the yarn may require, by changing the pinion governing the speed of the geared dial hand, the delivery remaining constant. The uniformity of the sliver or its grist from yard to yard can only be assured by the method of spreading, for the degree of uniformity attained is inversely as the size of the pieces into which the fibre is divided for spreading and directly as the amount by which these pieces overlap each other. The shorter the fibre, the more closely together should the pieces be spread, and the closer together they are, the smaller must the pieces be to produce a sliver of given weight. Thin places, if not actually gaps, in the sliver will always be present if the draft of the board be too long, or if the pieces be not sufficiently closely spread. Short fibre requires a short draft while long fibre will stand a longer one.

The following are particulars of a spread-board which will serve for slivering jute line: Rows of gills and leathers, 4; deliveries, 1; length of reach, 42 in.; breadth of gill, 7 in.; width of conductor, 5 in.; length of gill pin, 1¾ in. out; pins per inch in gill, 3 (2 rows); pitch of screw, ¾ in.

The patent automatic spreader (as illustrated in fig. 17) has been specially designed to work in conjunction with the automatic hackling machine described on p. 31, but has not yet generally been adopted for jute. It is a single sliver spreader by means of which the pieces are drawn from the holder

without disturbance of the fibres and laid one upon another with such regularity of overlap and with such evenness of thickness throughout their width, that the resulting sliver is more level than can be produced by hand spreading. In the

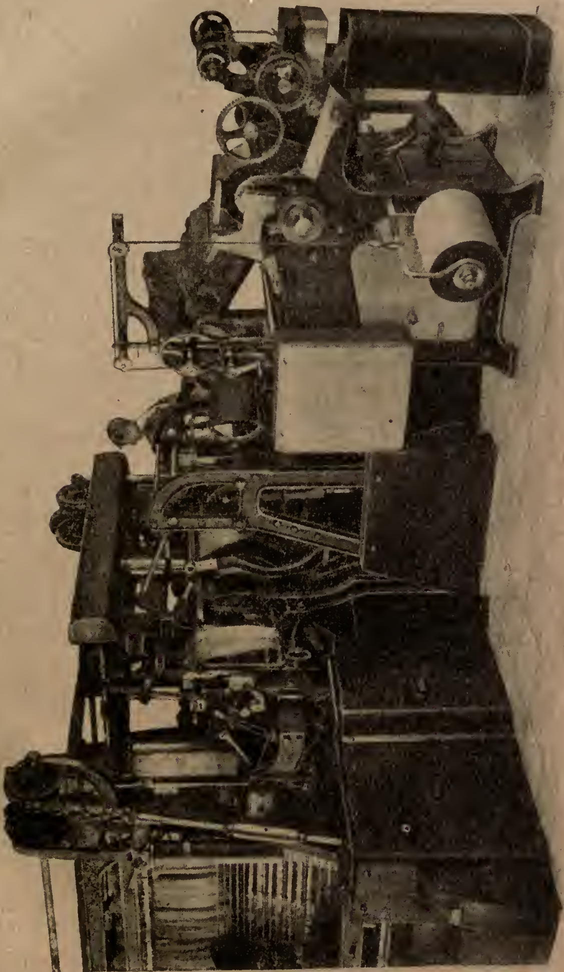


FIG. 17.—Combined automatic spreader and hackling machine.

event of a holder presenting itself to the spreading apparatus without any fibre in it, the spread-board is automatically stopped for the time of one lift of the head of the hackling machine, and thus no irregularity of the sliver occurs. Any

correction which may be required at the commencement of a new parcel due to change in length of fibre, change in weight of piece, or yield of hackled fibre can be quickly made by moving a handle on the automatic spreading apparatus. A single sliver spread-board or sliver formed has been specially designed to work in conjunction with the patent automatic spreading apparatus, and is seen in the illustration. Its reach is usually 32 in., pitch of screw $\frac{5}{8}$ in., and the diameter of drawing roller 4 in. The sliver is 14 in. wide if the hackling machine holders are 11 in. long and considerably wider for 16-in. holders, the pressing rollers being 16 to 20 in. wide respectively. It is so light and limber that it readily contracts when passing over the sliver pulley of the next drawing frame, and then enters the back conductor of an even thickness throughout its width. The rise and fall of the top feed roller, due to changes in the thickness of the entering fibre, is taken advantage of by connecting its weight lever to an indicator, the dial of which is graduated to represent so small a rise or fall in thickness as 1 per cent. This indicator shows the overlooker or feed attendant of the hackling machine whether each parcel of fibre is giving the required thickness of sliver and consequently the required weight of can. In order to readily make the necessary change in the speed of the spread-board to give the amount of overlap suitable to the length of the fibre in one parcel as compared with that of another, the spread-board is driven through a change speed gear box with indexed handle, so that the speed can be instantly set for any length of fibre. A can packing apparatus may be seen in the illustration which lays and packs the sliver so regularly into the can that over 50 lb. weight can be put into a can 38 in. by 16 in. by 12 in. In order to facilitate the handling of the heavy pressing roller, a swinging crane is attached to the spread-board with a friction retaining pawl by which the attendant can easily place the roller in position by unwinding the winch handle.

A further improvement consists in the addition of mechanism for automatically adjusting the amount of draft between the drawing rollers and the feed rollers with any change of thickness of material passing through the latter. The arrangement is such that the change of speed of the drawing rollers is delayed until the material that caused the displacement of the feed rollers has moved forward to or near to the nip of the drawing rollers. This is accomplished by means of an automatically shaped cam wheel, driven from the feed roller shaft. The wheel carries a number of pegs adapted to slide through

holes bored transversely through the rim of the wheel. The position of the pegs relatively to the wheel is governed by a pivoted shoe connected through the link to a lever moved by the rise and fall of the top feed roller. The pegs carried round by the wheel engage (after the necessary lapse of time, regulated by the speed of the wheel) a second shoe connected through links and lever with a belt fork which regulates the position of a belt upon a pair of speed cones. The pegs are locked in their adjustable position by an eccentric gripping wheel. Thus the pegs are prevented from shifting while they do their work upon the cone belt. The drawing rollers are driven through a differential gear box from the cone pulley A relay motion similar to that of a water turbine governor is inserted between the shifting level and the belt fork. Great regularity is obtained throughout the length of the sliver by means of this draft regulating motion.

CHAPTER V.

CARDING.

Carding being a cheaper process than hackling and spreading, just described, for splitting up the fibre and producing a sliver, it is practised upon nearly 100 per cent. of the jute produced. Although the length of the fibre is thereby reduced and a like degree of parallelism of the fibre unobtainable,

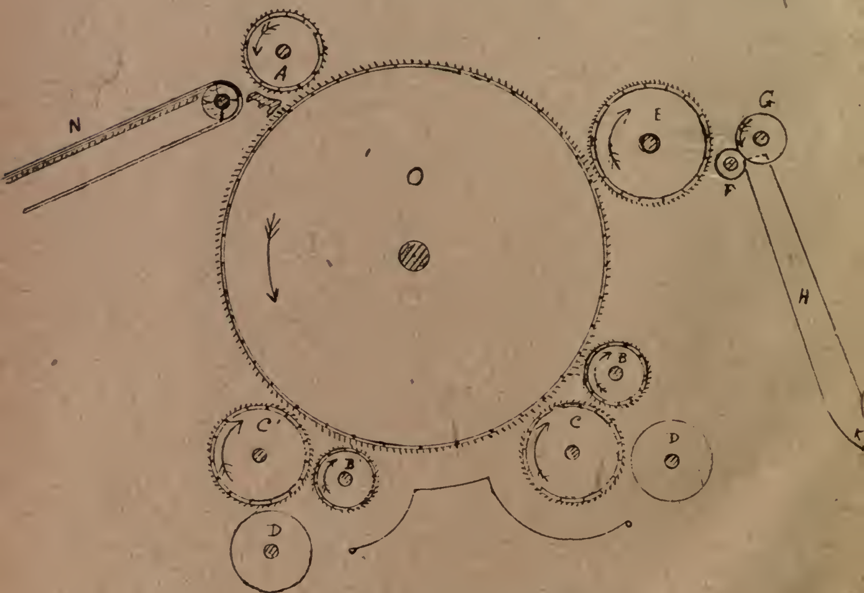


Fig. 18.—Jute breaker card.

yet with such a cheap raw material, low cost of manufacture, except in special cases is a predominant consideration.

In the Dundee and Calcutta jute mills, jute is broken up, carded and slivered by means of cards, such as shown in figs. 18, 19, 20 and 21. The first two shows the breaker card which does most of the breaking up and prepares the material for the finisher card represented by the latter figures.

As it will be seen, the breaker card consists of a cylinder O, usually 4 ft. in diameter and 6 ft. in face, round which are placed rollers called respectively shell feed roller A, workers B, and strippers C, doffer E, drawing off rollers F and G, and delivery rollers L and M. Although the feed rollers, workers, strippers, cylinders and doffer do not all revolve in the same direction clockwise, yet the peripheries of these rollers and the cylinder travel in the same direction at the point where they nearly touch. The feed roller A receives the jute from the feed sheet N, upon which it is spread by hand and delivers

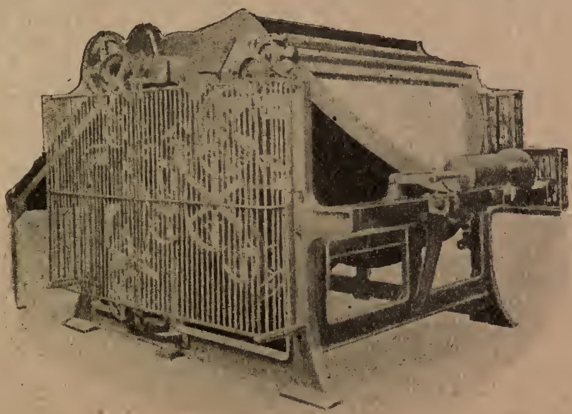


FIG. 19.—Breaker card as made by Messrs. Fairbairns, Leeds.

it to the cylinder O, the fibre passing between the feed roller and the shell shown, as it is fed in and, retarded by the pins of the feed rollers, is combed out and broken up by the cylinder pins as it passes over the edge of the shell, a sort of iron trough which surrounds the lower part of the feed roller. The two pairs of workers and strippers shown, open the material still further before it reaches the doffer, which is stripped by rollers which catch the long "braird" standing up upon the doffer, draw it off and pass it down in the form of a broad fleece to the calender and delivery rollers shown, through an inclined and contracting zinc conductor H. The feed sheet is of leather or of canvas. The shell is of cast iron, and its edge approaches parallel to and close to the face of the cylinder, which cylinder turns at a speed of about 180 revolutions per minute. The cylinder is likewise of cast iron, sometimes lagged with heavy wooden lags underneath the beech staves

or lags set with needle-pointed steel pins at the rate of about six points per square inch of surface, and sometimes stiffened by a sheet steel face.

The feed roller, workers, strippers, doffers are clothed in a similar manner, or with steel-covered leather filleting set with steel or iron wire teeth put in pairs in form of a staple. The roller pins are much longer than those of the cylinder, since it is their function to hold the fibre, for which reason also those of the workers, especially when set in leather, are given what is known as a knee bend. Workers and strippers are set close together and to the cylinders in pairs, the strippers

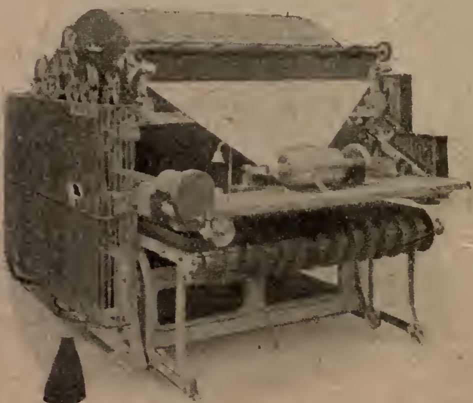


FIG. 20.—Jute finisher card.

being in advance of the workers, relative to the direction of motion of the cylinder. The pins of the cylinder are inclined towards the direction of motion in order to hold the material. The pins of the workers oppose those of the cylinder, and consequently comb, clean and render the fibres parallel as they are held by the cylinder pins. In doing so the workers retain much tangled fibre, lumps, &c., which they carry round until they are cleared by the strippers, which have a surface speed fifty to one hundred times as great as their workers. The angle of the stripper pins is in the direction of rotation, so that they retain the material until they are themselves stripped by the cylinder revolving at seven or eight times their surface speed. The doffer acts in a similar manner to a worker, and is stripped by a pair of smooth leather-covered or scored rollers, F, G, as described.

The angles of pins most usually employed are: Cylinder 75° with the surface, feed roller 60°, strippers 30°, workers 40°, and doffers 35°.

The surface speed of the strippers of the jute breaker card is from 50 to 100 times that of the worker and must be less than that of the cylinder.

The following is a very usual setting of the rollers to the cylinder and to each other: Feed roller to shell, 8 w.g.; feed roller to cylinder, 15 w.g.; shell to cylinder, ⅜ inch. No. 1 worker to cylinder, 12 w.g.; No. 2 worker to cylinder, 14 w.g.; workers to strippers, 16 w.g.; doffer to cylinder, 16 w.g.; drawing-off rollers to doffer, 8 w.g.

Its producing power is about 50 cwt. of material per day, its net weight about 8 tons. The floor space occupied, 14 feet 6 inches by 9 feet.

The jute finisher card, which is fed with slivers furnished by the breaker card, may be a full circle down-striker card, as illustrated in figs. 20 and 21, or an up-striker half-circle card with delivery at the opposite side from the feed, as shown in fig. 22. It has usually a shell feed and either three or four pairs of rollers, differing from the card last described principally in the number of pairs of rollers which surround the cylinder and in the fineness of the clothing of cylinder and rollers. Whether up or down striker, these cards have a shell feed A. The speed of the cylinder O is about 180 revolutions per minute; of the strippers C, 150 revolutions per minute; and of the workers B, 20 revolutions per minute. Its productive power is about 21 cwt. per day, and the floor space occupied 16 feet by 8 feet.

It will be noticed that the shell feed roller of these cards is much smaller than in the breaker card (fig. 18), and that the sliver produced is in the case of full circle cards conducted round a horn W along a sliver plate Z, parallel with the face of the card and above the feed sheet, to a side delivery V.

The setting of the jute finisher card for hessian yarns is approximately as follows: Feed roller A from cylinder O and shell, 15 w.g.; shell from cylinder, ⅜ to ¼ inch; first and second workers to cylinder, 12 w.g.; third and fourth workers to cylinder, 14 w.g.; strippers to cylinder, 16 w.g.; doffer to cylinder, 17 w.g.; drawing-off roller F to doffer, 10 w.g.; doffer to cylinder, 17 w.g.; pitch of cylinder pins 7/16 inch.

The card sets used to obtain these settings are pieces of sheet steel or brass, usually about 12 inches long and 3 inches

broad, and stamped No. 10, 12, 16, &c., according to their thickness b.w.g.

If workers and strippers are to be set No. 16 between, use No. 16 set and so on.

This card is, as we have said, fed by slivers from the breaker card, either direct from the cans or formed into a ball upon the sliver lap machine.

This sliver lap machine consists merely of a framing carrying a calender roller, 22 inches to 30 inches wide, to compress the lap and a geared spindle upon which the lap

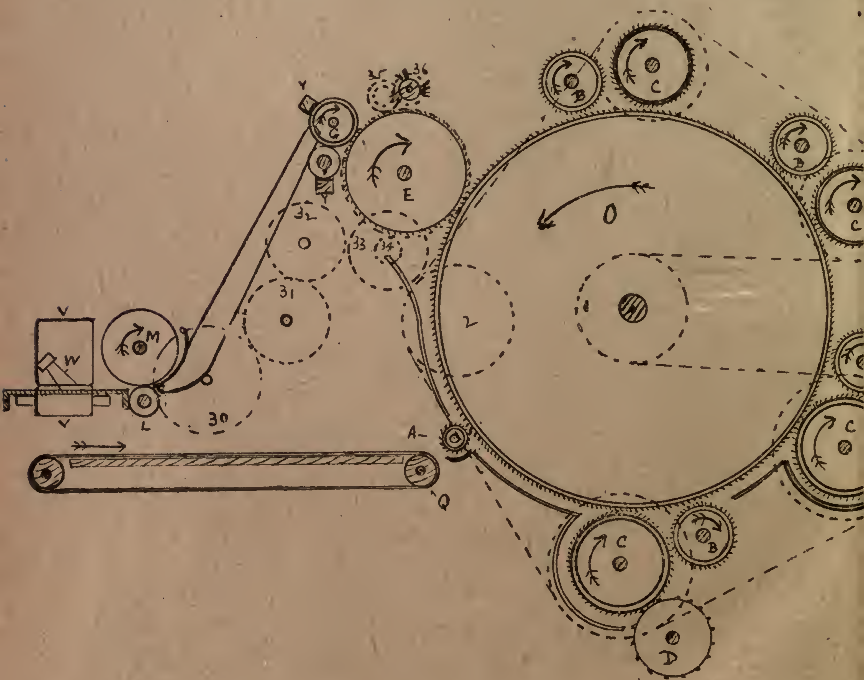


FIG. 21.

is wound. Cans of sliver from the breaker card to the number of 6 or 12 are placed at the back, and the slivers evenly distributed by conductors over the required breadth. They thus form an even sheet, 22 inches or 30 inches wide, which is compressed and wound into a lap or roll, say, 18 inches in diameter. A 6-ft. card requires either two or three of these laps, according to their width, to be put across its face.

In order that the surface speed of the lap or the rate at which the slivers are drawn from the cans may be constant, the bobbin is driven through bevel and spur gearing from a

vertical shaft which is itself driven by a friction plate and bowl. As the lap increases in diameter, the friction bowl is raised nearer to the centre of the friction disc and the lap or bobbin is driven more slowly, but at a like surface speed.

A modern sliver lap machine stops automatically when the required diameter of ball is attained or length of sliver is rolled up. At the same moment, one of the side binding plates is removed laterally from its normal position so as to release

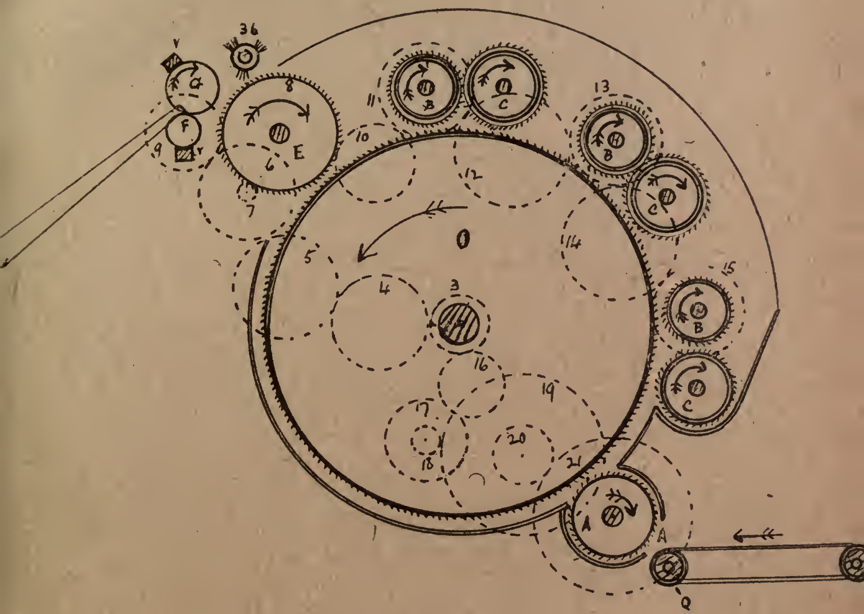


FIG. 22.

the pressure upon the completed ball, which is thus permitted to fall with its lap roller by gravity into a suitable receiver, ready for its removal from the machine to the finisher card.

Sliver of uniform and suitable weight is obtained from the jute finisher card by spreading a given weight of jute, called a "dollop," upon a given length of feed sheet of the breaker card. Slivers fairly uniform in weight per unit of length are thus obtained, which, being doubled together upon the sliver lap machine, produce a very level feed.

The word "dollop" is the name applied to the bundles of jute laid upon the feed sheet of the jute breaker card in one round of the clock attached to the feed roller. The weight of

this dollop may be so regulated as to produce rove of any desired weight.

In order to ascertain the necessary weight of dollop, the "length of the clock" or the length of the feed sheet which moves forward while the hand of the clock makes a complete revolution must first be found. The length of the clock may be calculated in one of two ways, i.e., either from the circumference of the feed roller at the centre of pins or from the circumference of the "plaiding roller" K, or the driving feed sheet roller P. This roller is usually 4 in. in diameter, but half the thickness of the feed sheet must be added to each side, making its effective diameter $4\frac{1}{8}$ in., or its circumference 12·95 in.

Taking the first method, there is usually a treble threaded worm on the end of the feed roller, which gears into a worm pinion of 42 teeth, on the pap of which is a pinion of 36 teeth gearing into a similar one on the arbour of the clock. Thus one revolution of the clock hand is equal to $\frac{36 \times 42}{36 \times 3} = 14$ revolutions of the feed roller. If the latter is $10\frac{1}{2}$ in. in diameter, or 32·98 in. in circumference, the length of the clock is $\frac{32{\cdot}98 \times 14}{36} = 12{\cdot}82$ yards.

By the second method: If there is a pinion of 46 teeth on the end of the plaiding roller and a wheel of 114 teeth on the end of the feed roller and gearing with it, the gearing of the clock remaining as before, the plaiding roller will make $\frac{36 \times 42 \times 114}{36 \times 3 \times 46}$ = nearly 35 revolutions for one of the clock. If, as we have said, the effective diameter of the plaiding roller is $4\frac{1}{8}$ in., and its circumference 12·95 in., the "length of the clock" works out at $\frac{12{\cdot}95 \times 35}{36} = 12{\cdot}6$ yards.

The former method of calculation is the more correct, as the feed roller is given a slight lead upon the feed sheet to prevent choking, so that the actual length of the clock may be taken at 13 yards.

The next question to be solved is: What must be the weight of 13 yards of breaker card sliver to produce rove of the desired weight? To find this, we must work back from

the desired weight of rove in drams per 100 yards, multiplying by the drafts of the drawing frames and finisher card and dividing by the doublings. In this way we get the weight of 100 yards of breaker card sliver, and from that find the weight of 13 yards. Suppose that we find that the weight of 13 yards of breaker card sliver must be 2 lb., and that the draft, or relative surface speed of feed and delivery of the breaker card is 13, $2 \times 13 = 26$ lb. must be the weight of the "dollop." In practice, plus and minus allowances must be made for waste and bulking of the sliver, but generally it will be found that, if about 1 per cent. be added to the weight of the dollop, the rove or yarn will come out the right weight.

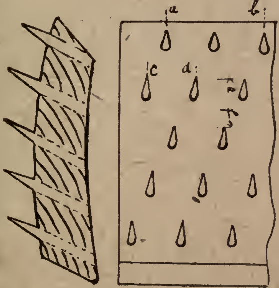


FIG. 23.

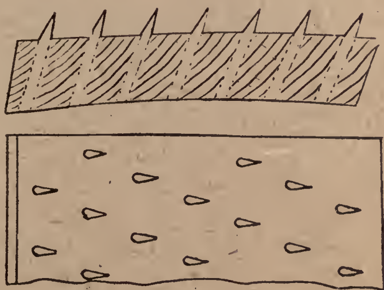


FIG 24.

In cards of this sort the surface speed of the cylinder is approximately 2,500 ft. per minute, workers 47 ft. per minute, strippers 420 ft. per minute, doffer 83 ft. per minute, tin cylinder or dummy rollers 47 ft. per minute, and drawing off roller 170 ft. per minute. The draft between the doffer and the drawing off roller is consequently approximately equal to 2.

As will be seen from figs. 23 and 24, the clothing of the jute card is of wood, the card pins being round or needle-pointed and ground prior to their insertion in the wood staves or lags which are generally of thoroughly seasoned oak or beech and sometimes metal covered. These staves or lags are frequently $\frac{3}{4}$ in. thick and 24 in. long, which means three rows upon a cylinder or roller of 6 ft. face. The "lags" are hollowed in the inside and rounded on the face to the circle of the cylinder or roller upon which they are to be placed and to which they are screwed.

The diameter of the wire from which the jute card pins are made varies from 12 b.w.g. to 16 b.w.g., the cylinder pins

of the breaker card being usually 12 w.g., while those of the doffer of the finisher card may be 16 w.g. That part of the shank of the pin which is intended to be in the wood is parallel, the projecting point only being taper. The angle at which the pins are driven through the stave depends upon the work of the roller concerned. The angles most usually employed are—cylinder 75° with the surface, feed roller 60°, strippers 30°, workers 40°, and doffer 35°. Fig. 24 represents a cylinder stave in section and in plan. Fig. 23 gives similar views of a worker stave.

The usual pitch of pins (*c*, *d*, *e*, *f*, fig. 23), size of pins, and length of pin out of cylinder, feed roller, 1st and 2nd strippers, and workers and doffers of a breaker card may be as follows:—

	Pitch	Size of pins	Length of pin out of stave
Cylinder	$\frac{5}{8} \times \frac{5}{8}$ in. ...	No. 12 × 1 in. long ...	$\frac{5}{16}$ in.
Feed roller ...	$\frac{7}{16} \times \frac{7}{16}$,, ...	,, 12 × $1\frac{1}{4}$,, ...	$\frac{3}{8}$,,
No. 1 stripper ...	$\frac{1}{2} \times \frac{1}{2}$,, ...	,, 1 × $1\frac{1}{4}$,, ...	$\frac{1}{4}$,,
No. 2 stripper ...	$\frac{1}{2} \times \frac{1}{2}$,, ...	,, 13 × $1\frac{1}{4}$,, ...	$\frac{1}{4}$,,
No. 1 worker ...	$\frac{7}{16} \times \frac{7}{16}$,, ...	,, 13 × $1\frac{1}{2}$,, ...	$\frac{3}{8}$,,
No. 2 worker ...	$\frac{7}{16} \times \frac{7}{16}$,, ...	,, 13 × $1\frac{1}{2}$,, ...	$\frac{3}{8}$,,
Doffer	$\frac{3}{8} \times \frac{3}{8}$,, ...	,, 14 × $1\frac{1}{8}$,, ...	$\frac{5}{16}$,,

Similar figures applied to a jute finisher card would be:—

	Pitch	Size of pins	Length of pin out
Cylinder	$\frac{7}{16} \times \frac{7}{16}$ in. ...	No. 15 × $\frac{7}{8}$ in. long ...	$\frac{9}{32}$ in.
Feed roller	$\frac{3}{8} \times \frac{3}{8}$,, ...	,, 14 × $1\frac{1}{8}$,, ...	$\frac{3}{8}$,,
First and second strippers ...	$\frac{7}{16} \times \frac{7}{16}$,, ...	,, 14 × $1\frac{1}{8}$,, ...	$\frac{7}{32}$,,
Third and fourth strippers ...	$\frac{3}{8} \times \frac{3}{8}$,, ...	,, 15 × $1\frac{1}{8}$,, ...	$\frac{7}{32}$,,
First and second workers ...	$\frac{3}{8} \times \frac{3}{8}$,, ...	,, 14 × $1\frac{1}{2}$,, ...	$\frac{5}{16}$,,
Third and fourth workers ...	$\frac{5}{16} \times \frac{5}{16}$,, ...	,, 15 × $1\frac{1}{2}$,, ...	$\frac{5}{16}$,,
Doffer	$\frac{5}{16} \times \frac{1}{4}$,, ...	,, 16 × 1 ,, ...	$\frac{9}{32}$,,

It will be seen that the distance from pin to pin in a row (*c*, *d*) and the distance apart of rows (*e*, *f*) is usually equal. This being so, if the pitch of pins is $\frac{1}{2}$ inch, or the pins per inch (*a*, *b*) in the row 2, the pins per square inch would be $2 \times 2 = 4$. Care should be taken in counting the pins per inch in the row not to include too many pins. This may be avoided by placing the point of the first pin upon the zero mark and leaving that pin out of the count. If the pins are $\frac{7}{16}$ in. pitch there will be sixteen pins in 7 in. If $\frac{3}{8}$ in. pitch, eight pins in 3 in. and so on.

The bevelling of the edges of the staves is shown in the figure. This bevelling permits of the staves being closely and securely fitted. It is most important that the staves be securely and carefully screwed on the cylinder and rollers. If a stave gets loose much damage will be done.

CHAPTER VI.

DRAWING AND DOUBLING.

A FAIRLY uniform sliver of a known average weight having now been formed by means of a card, it next remains to render this sliver still more uniform and level in weight from yard to yard by means of repeated doublings, and at the same time to reduce it down more nearly to the size of yarn by drafting or drawing out. Doubling renders the sliver more uniform, since thick parts in one sliver often partially or wholly coincide with the thin places in another sliver, and the result is an average of all, and considerably more level than any of its component slivers.

The drawing frames upon which this drafting and doubling is done may be such as shown in fig. 25, which shows a jute

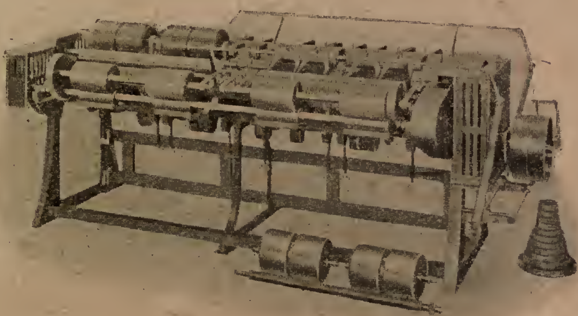


FIG. 25.

drawing frame as made by Messrs. Fairbairn Macpherson, of Leeds. Each machine is made up of two or more "heads" or complete gill boxes. Each "head" has a separate set of fallers or gill bars. Upon each faller or bar are four, six or eight rows of gills, the bars being actuated either upon the screw or push bar system.

The push gill bar motion is so named because, after being raised in the teeth of a pinion, one bar pushes the others along a horizontal slide until it enters the teeth of a similar pinion, which supports it until the bottom slide is reached. The opposite ends of alternate bars have crank-shaped lugs or pieces attached to them, which, while the round of the bar is

in the teeth of the pinion, are guided in an outside groove which controls and renders perpendicular the ascent and descent of the gills. In a newer type the bars are linked together at alternate ends by brass links.

In the screw gill system, the fallers or gill bars are thin but deep bars extending parallel with the feed rollers, and resting at the ends upon top and bottom slides, the ends themselves being formed to work in the square threads of revolving screws, by means of which those upon the top slide are moved forward from the feed rollers and those upon the bottom slide in the opposite direction. The bottom screws are coarser, since they are only employed to conduct the fallers back again to the feed rollers, where they are raised by a tappet into the top screw and on to the top slide, where they conduct the fibre forward to the boss rollers and are knocked down by another tappet into the bottom screw and on to the bottom slide, there to repeat the motion. Springs or weighted guides are provided at either end of the slides to regulate the rise and fall of the bars front and back. The back end of the top slide is shaped to work in a groove in the faller end to assist in keeping the fallers in correct position. The guard or guide at the front works in the same groove with a like object. In consequence of the wear and tear of fallers and slides, brought about by the fall of the former, the screw gill drawing is usually proved with "reception levers" actuated from the screw, which receive the faller as it leaves the top slides and deposits it upon the lower. There are usually four or six rows of gills per head, and as many leather-covered pressing rollers as there are rows of gills. These pressing rollers rest upon a metal drawing roller opposite each row of gills, the leather roller being held tightly against the boss or drawing roller by means of pressure exerted through a lever weight, connecting rod and hanger, which hooks over the axle of the leather pressings between each pair of bosses or by means of two levers exerting pressure upon either end of short axles. In front of the drawing rollers is the doubling plate, and in front of that again the delivery or calender rollers.

When on the screw gill principle, motion is given to the screws from the back shaft, which runs the full length of the frame. A safety pin is often put in the draft change wheel, which drives the back shaft, so that should a faller stick, the pin shears, the fallers cease to move and a break is prevented. In order that the sticking of a faller may not bring about the stoppage of the whole frame, a double back shaft may be in-

serted for each head and driven through a pin wheel, so that only one head in which a stick occurred is stopped by such an accident. In the ordinary frame, should the adjustment of one head be necessary, the whole frame must be stopped, for the rollers are continuous throughout the frame and only the fallers are independent.

Fig. 26 gives a general view of the "Ring" jute drawing frame as made by a Scotch firm; while fig. 27 shows the arrangement of the internal toothed ring or gill bar carrier, which is the chief feature of the machine. The ring is 3 in. wide, and the teeth $2\frac{1}{2}$ in. wide and machine cut. The gill bars, in the circular part of their travel, rest in the teeth of

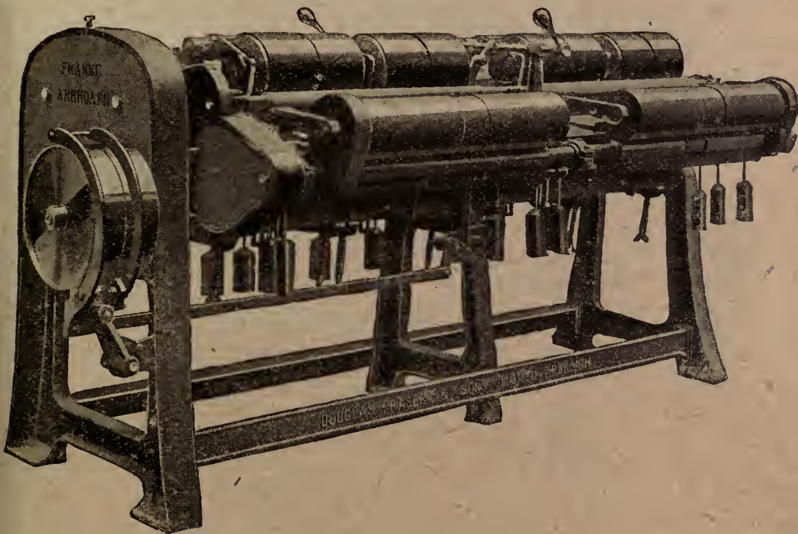


FIG. 26.—Jute drawing frame.

this ring, and are carried without any sliding friction. When near the horizontal diametric line they leave the teeth and are pushed along that line to the opposite side, where they are caught by the downcoming teeth, and pass quite smoothly over a comparatively sharp corner. The cam slot controlling the canting of the bar, by means of the crank on their ends, is milled out of the solid, and causes the pins to enter and leave the sliver in an almost vertical position. The "pitch pin" pinion is on the main shaft which drives the bar carriers. This shaft is outside the path of the gill bars, and is geared into shrouded teeth in the outer circumference of the carrier rings, which, as well as the top and bottom races for the bars,

have broad bearing surfaces. The gill bars are $\frac{7}{8}$ in. diameter, and are of triangular section at the gills. They may be easily lifted out without undoing any screws. The crank pins on the ends of the bars measure $\frac{15}{16}$ in. from centre of bar to centre of pin.

Among the advantages claimed for this arrangement is a saving of several inches in the length of the frame, allowing wide passes when arranged in the usual Calcutta style.

Fig. 28 shows the arrangement of a chain gill bar drawing frame. It will be seen that in this frame the gill bars are linked together into an endless sheet and carried round by pairs of sprocket wheels on either end of front and back shafts.

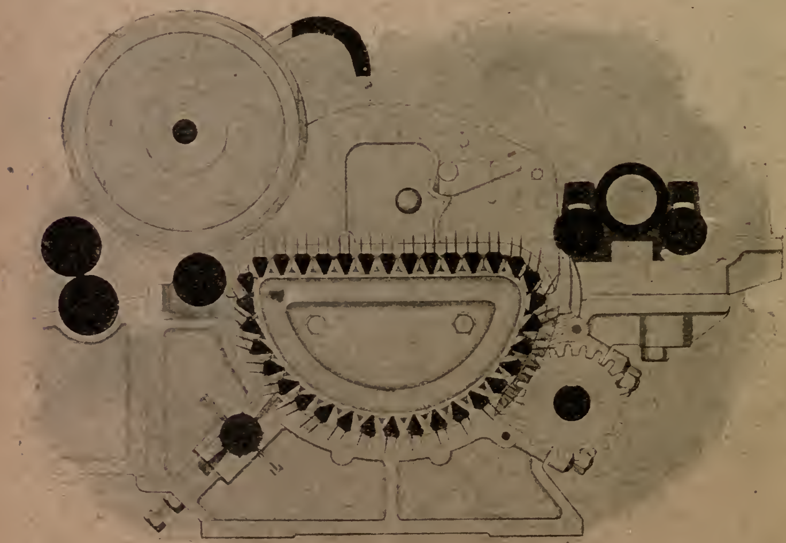


FIG. 27.

A number of other details are clearly shown in this figure, i.e., the back conductors, feed and jockey rollers, the compound levers and hangers, by means of which pressure is applied to the leather-covered pressing roller, the "sleeking rollers" with revolving rubber, which rubbers may also be noticed on the feed rollers, as may also the "dead" rubbers under the lower drawing, sleeking and delivery rollers, and on top of the calender roller and leather-covered pressing roller. The levers, by means of which these are held in place, are also shown, as is also the eccentric arrangement by

means of which the pressure is taken off the drawing rollers, prior to a prolonged stoppage, by the one operation of turning a hand-wheel on the end of the eccentric shaft.

The form of double feed or retaining rollers seen in this figure, with intermediate jockey roller, is the one generally

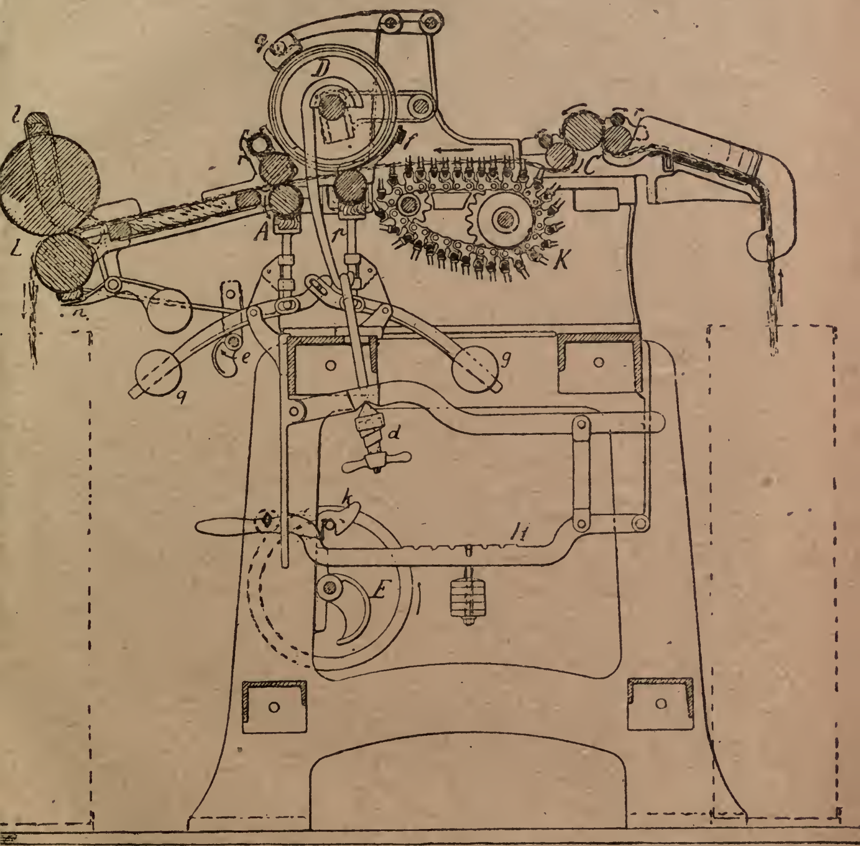


FIG 28.

used in jute drawing frames. The sliver is passed from the can, as shown, through a conductor, under the back feed rollers round the top of the jockey roller, and down under the front feed roller, where it is pinned by the gills. The jockey rollers are in short lengths, intended to carry either one or two slivers, and lie by their own weight upon and between the front and back feed rollers. A short jockey

roller has the advantage that, if a lap forms on the roller, it raises it and prevents it holding other slivers firmly, if required to do so. For this reason it is preferable to have the jockeys in such short lengths that they are required to carry but one sliver, when, if this laps, only one sliver is thereby affected.

The usual cause of lapping is some roughness on the roller caused by careless handling, letting it fall or roll on the gills, &c. If laps are to be avoided all rollers must be kept perfectly smooth. The pressing rollers are of metal and fluted, or else covered with leather which is neatly pegged and cemented to a cast iron boss.

Rubbers are used to prevent loose fibres from lapping round any of the revolving rollers between which they pass. They are usually of the "dead" type, pressing upon the roller either by their own weight, when applied to the upper side of a roller, or pressed upwards by means of springs or levers when placed underneath a roller. The body of the rubber is of wood or metal, or both. The rubbing surface is covered with one or two layers of felt or thick flannel which is glued or pegged on. The rubbers must be thoroughly cleaned periodically. Care must be taken that the rubbers upon the pressing rollers are not too heavy, lest the proper revolution of these rollers be impeded.

The frames are sometimes provided with backs which carry sliver guides over which the slivers pass, from the cans to the feed rollers, or they may pass direct from the cans over a smooth plate which carries the back conductors. If single slivers are being worked, there is but one sliver in each row of gills, but when double slivers are worked there are two. Occasionally three slivers are put up per row, but this is exceptional.

The slivers pass through the back conductors, feed rollers and gills, and are drawn out by the boss roller, doubled together over the sliver or doubling plate and delivered into cans by the delivery or calender rollers. There may be one or more deliveries per head, according as the slivers from two, three, or four rows of gills are doubled together.

Sleeking rollers are a small pair of rollers seen just in front of the boss and pressing roller in figs. 27 and 28, and lying parallel with the said rollers. Their function is to aid to some extent the drawing action of the boss roller and to prevent loose fibre from licking up on the drawing pressings.

"Singling" or light slivers due to the unnoticed breaking down, running out and through of a sliver from the back of

a drawing frame may to a large extent be avoided by the application of automatic stop motions which bring about the stoppage of the frame or of a single head only if the frame be built upon the independent head system which has been adopted in some Continental mills. Under this system, the slivers on their way to the back or feed rollers pass over the channelled ends of levers which are balanced on a knife edge. The tail end of these levers is the heavier and falls as soon as the weight and tension of the sliver is removed. When a sliver fails or breaks this heavy tail end falls into the path of an oscillating notched bar, or revolving notched roller, and brings about the putting out of gear of the cone friction clutch driving that head until the sliver is replaced.

A system of preparing machines is a set of machines which work together and supply each other. A jute system which is supplied with sliver by a finisher card usually consists of two drawings and a roving frame or gill spinner. A compound system is one composed of drawing frames of a sufficient number of heads to supply two roving frames. Its chief advantage is a small saving in first cost and in floor space occupied as compared with two single systems of combined like capacity. The disadvantage of a compound system is that the details of each compound drawing must be practically the same throughout, and that it is advisable to keep the whole system on the same or similar work. A compound system is quite satisfactory when large quantities of the same grist and quality of yarn have to be produced and kept on the frames for a considerable time. A compound system effects a saving in floor space since a four-headed compound drawing will occupy less floor space than two two-headed drawings, since in the former case the pulley and gearing occupy practically no more space than they do on each of the single frames.

Since the yarn is cheap and coarse, two drawing systems are deemed sufficient for carded jute yarns, more drawings and doublings increasing the cost of production. As a general principle, however, and one which should be adopted for fine yarns, the more drawings there are the more doublings may be put in. Since the levelness of a yarn is in direct proportion to the number of doublings put in, it follows that the more drawings are used the better the yarn will be unless the material is such as to be weakened and shortened by excessive gilling.

Drafts ranging from 3 to 4 are usual on push bar and

circular drawing frames, while on spiral drawings 8 is not deemed too long, the nips being much shorter.

While the speed of fallers in spiral drawings should not exceed 200 drops per minute, push bar and circular drawings may pass up to 350 gill bars per minute.

When the surfaces of both drawing and pressing rollers of jute drawing frames are metal, the rollers are said to work "hard to hard" and are fluted with a round top and bottom flute, the flutes working into each other. Since the sliver passing between these rollers is pressed into the flutes the effective circumference or diameter of the drawing roller is increased by, say, 20 per cent. When the pressing roller is leather-covered it usually works upon a drawing roller with V flutes said to be scratch fluted. This scratch fluting is done irregularly so that the pressing roller may not become fluted by being pressed continuously upon similar flutes.

Automatic motions should always be fitted to the boss or drawing roller of drawing frames, and other following machines of the same sort, to produce a traverse movement backwards and forwards, or on end, so as to prevent the drawing roller from getting grooved at the sides of the pressing roller. The application of such a shifting motion makes the drawing roller remain in good working order much longer. It is accomplished by means of a collar block, shifted by an ecentric actuated very slowly through worm gearing by means of a ratchet wheel moved intermittently by a pawl, and connecting link and crank usually on one of the slow running gear wheels.

The cause of the grooving of the drawing roller if a traverse motion is not applied is the friction of the edge of the pressing roller, for the thickness of the sliver between the rollers gives the working surface of the pressing roller a greater surface speed than that of the bare drawing roller. The edges of the pressing roller retain their original diameter, whereas the central part of the face becomes compressed and reduced in diameter, so that it will be seen that the edges of the pressing roller will soon touch the surface of the drawing roller, and produce the grooving referred to on account of their superior surface speed.

The draft of a drawing frame, like that of other similar machines, is the relative speed of feed and delivery. It is found by finding out the length delivered by the delivery roller, while the feed rollers make one revolution, and then by dividing by the circumference of the feed roller.

An example will suffice to show the method by which the theoretical draft may be calculated. A certain screw gill drawing has a back or feed roller $1\frac{15}{16}$ in. in diameter. A wheel of 69 teeth is keyed upon the end of this roller and called the feed or retaining roller wheel. This wheel drives a stud pinion of 25 teeth, compounded with a stud wheel of 68 teeth. The latter drives the back shaft through a pinion of 25 teeth called the back shaft pinion. Upon the other end of the back shaft is fixed the "change" wheel, which we will say has 35 teeth. This draft change wheel drives the boss roller pinion of 43 teeth through a series of simple spur carriers or intermediates. The diameter of the boss or drawing roller is $2\frac{1}{2}$ in. The circumference of both boss and feed rollers bearing the same fixed ratio to their diameters, we take their diameters instead of their circumference and find the value of $\frac{69 \times 68 \times 35 \times 2\frac{1}{2}}{25 \times 25 \times 48 \times 1\frac{15}{16}}$ to be 7·88, the draft of the frame. The actual draft is rather less than this, being influenced by the thickness of the material between the rollers.

The undrafted sliver held by the back roller of the drawing frame is, of course, thicker than the attenuated sliver held by the boss roller. Hence the actual draft is shorter than the theoretical. To allow for this factor when calculating the draft, the diameter of the roller should, properly speaking, be considered to be augmented by half the thickness of the sliver passing over it.

The draft of the patent circular drawing frame may be found in a very similar way. For instance, the retaining roller wheel may have 15 teeth, stud pinion 15, stud wheel 27 teeth, draft change wheel 52 teeth, stud wheel compounded with the last 120 teeth, and delivery roller pinion 17 teeth. If both feed and drawing rollers be 3 in. in diameter the theoretical draft will be

$$\frac{15 \times 27 \times 120 \times 3}{15 \times 52 \times 17 \times 3} = 3·66.$$

In this circular drawing frame above referred to the gill bars are carried round by radially slotted discs at either end. To properly pin the sliver as it leaves the feed rollers the gill bars are raised in the radial slots by cam-shaped slides at either end. To cause the gills to leave the sliver sharply and close to the nip of the drawing rollers, the cam slides come to an abrupt end and the gill bars fall by gravity to the inside end of their slots.

CHAPTER VII.

THE ROVING FRAME.

THE roving frame is intended to still further attenuate the sliver from the finishing drawing frame, so that it may be spun into a comparatively fine yarn, with a comparatively short spinning draft.

The drafting arrangements of the roving frame are practically the same as in the drawing frames and gill spinners already described. The gills are, however, finer than those of the preceding drawing frame and the front conductor proportionate in width to the weight of the sliver produced. The gills are of the screw, link, slide, ring and rotary types. The following are the particulars of a screw gill roving frame

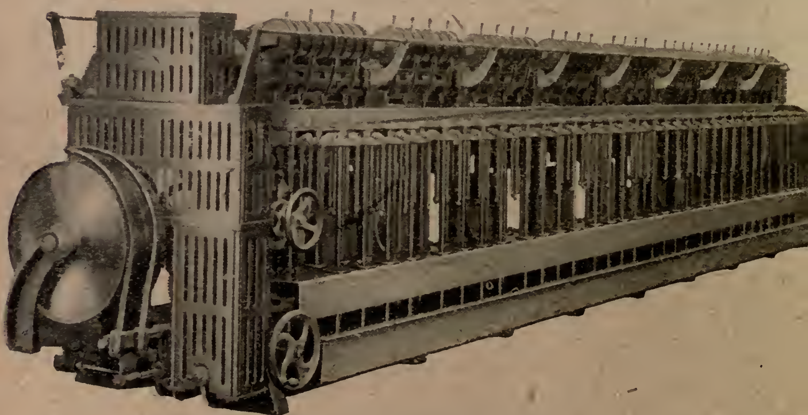


FIG. 29.—Jute roving frame.

frequently met with in Dundee: Seven heads of 8 spindles or rows of gills each—56 spindles in all—bobbins 10 in. traverse and 5 in. head; width of gills 2 in., 6 pins per inch (2 rows); pitch of screw $\frac{1}{2}$ in.; reach 10 in. Pressing rollers of metal and faced with leather on flat. Speed of spindles, 700 or 800 r.p.m.

The roving frame differs from a drawing frame, in that the sliver as delivered, instead of being deposited in a can, is slightly twisted and wound upon a bobbin. This is done because, when the sliver reaches this frame, it has been drawn out to such an extent that if it is to be drawn out still further

it must be given a slight twist to strengthen it, and must be wound upon a bobbin or spool.

The spindles are of steel, about 3 ft. long, and ¾ in. diameter. The spindle "foot" rests in a brass step set in the step rail. The spindles are supported in a vertical position by brass collars fixed in the builder and are arranged in two rows. The collars should be long, projecting on the under-side below and on the upper-side level with the top of the builder, thus forming a sleeve or socket upon which the wharves or carriers may run without wearing the spindles. The length of the spindle must be at least 3 in. longer than twice the traverse of the bobbin, plus the depth of the builder and step rail from step to cover.

Jute roving spindles are invariably supported at the top by steadiers or hinged plates in which brass-bushed eyes are inserted. When the plates are brought down, the eyes pass over the spindle top and flyer head and a top bearing is thus provided for the spindles. The raising of the top steadiers permits the flyers and bobbins to be removed.

The spindle tops are fitted to receive the flyers, which are of wrought iron or steel. The mode by which the flyer is attached to the spindle top is such that it can be easily removed and replaced after "doffing" the bobbins, but at the same time remain firmly in position when working. Perhaps the best is the patent of Hattersley, the method employed being a spiral groove cut in the spindle top, the groove terminating in a round stop. This groove receives a small round button, fixed inside the socket of the flyer, the roving spindle keeping the button pressed against the end of the groove.

The neck and leg of the flyer are hollow, the latter being split to facilitate threading. The rove enters the throat and neck, passes to the leg through one or two lateral holes, and is then led through the flyer eye, which may be in curl form or be a ring fitted with steel or porcelain eyepiece.

The rove is usually passed direct from the hole in the neck to the leg of the flyer. Some spinners, however, prefer to pass the rove almost completely round the neck before leading it through the leg of the flyer, believing that in so doing they get a smoother rove and localize the tension and strain in the twisted portion.

A very fair speed for the spindles is 700 revolutions per minute. As the usual 10 in. by 5 in. bobbin is heavy, especially when filled with rove, the centrifugal throw of the rapidly revolving bobbin is considerable and tends to strain

the spindle and its bearings, especially when the builder raises the bobbin to the top end of the spindle blade. Consequently top steadiers are universally used on jute rovings. These top steadiers are hinged plates in which brass-bushed eyes are inserted. When the plates are brought down the eyes pass over the spindle tops and flyer heads, and a top bearing is thus provided for the spindles. The raising of the top steadiers permits the flyers and bobbins to be removed.

The speed of the spindles may be calculated from the speed on the line shaft by multiplying the speed of the latter by the diameter of the drum upon it and dividing the product thus obtained by the diameter of the frame pulley. The speed of the frame shaft is thus obtained, which, when multiplied by the number of teeth in the speed wheel and divided by the number of teeth in the spindle shaft wheel, gives the speed of the spindle shaft. The speed of the spindle shaft multiplied by the number of teeth in the bevels upon it and divided by the number of teeth in the pinions upon the spindles, gives the speed of the spindles, there being a like number of teeth in the bevelled and spur portions of the rose stud intermediate carrier pinions, if any. Thus, suppose that the line shaft makes 125 revolutions per minute, that the drum upon it is 36 in. in diameter, and the frame pulleys 20 in. in diameter, the speed of the frame shaft is then $\frac{125 \times 36}{20} = 225$ revolutions per minute. Suppose that the speed wheel has 90 teeth, and the spindle shaft wheel 30 teeth, the speed of the latter shaft is then $\frac{225 \times 90}{45} = 450$ revolutions per minute.

If the spindle shaft bevels have 28 teeth and the spindle pinions 18 teeth the spindles will make $\frac{450 \times 28}{18} = 700$ revolutions per minute. Of course, there is a train of intermediate gear or carriers between the spindle shaft wheel and the speed wheel which may be neglected in the calculation. As previously mentioned, there is also very often a double intermediate between the spindle shaft bevel and the spindle pinion which may likewise be neglected, if, as is usual, both its parts have a like number of teeth.

In frames of various makes the speed of the spindles usually bears a fixed ratio to that of the frame shaft.

In Lawson's it has been found to be as 2·8 : 1; in Fairbairn's 3 : 1; and in Combe's 2·4 : 1. The wharve or bobbin carrier consists of a round platform upon which the base of the bobbin rests. The under portion of the carrier is a bevel or spur pinion, by means of which motion is given to it from the socket wheel running loose upon the frame shaft. The wharve runs upon the top portion of the brass collar which surrounds the spindle. Its flat face has one or more pins projecting from its surface, which engage in corresponding holes in the base of the bobbin.

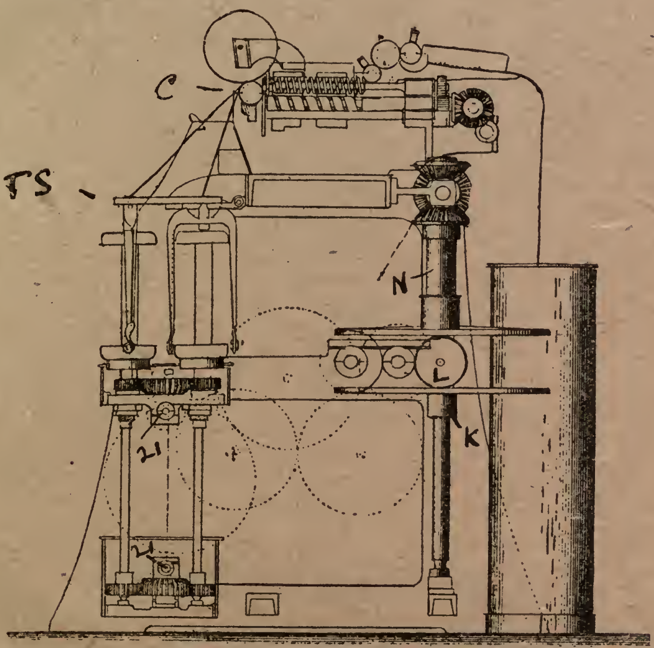


FIG. 30.

The bobbins have generally a barrel of ash with sycamore or beech ends. The bore of the barrel is chambered to reduce friction on the spindle. The most common size of bobbin in general use in the jute trade has a traverse or length of barrel of 10 in. and a head and base 5 in. in diameter, commonly called a 10 in. by 5 in. bobbin.

In jute preparing, the rove is laid upon the bobbin by the flyer, which travels quicker than or leads the bobbin. Since the rate of delivery is constant, the bobbin must run quicker when full than when empty, its diameter being greater. This

result is brought about by the use of a differential motion in connection with the bobbin winding mechanism of the roving frame, the bobbin being thereby also given a positive motion, so that a comparatively weak rove may be built upon the bobbin in a regular manner without strain. The speed of the bobbins, and consequently of the wharves, usually bears the same ratio to that of the socket wheel as does the speed of the spindles to that of the frame shaft. If the differential wheel were fixed, the socket wheel would revolve at the same speed as the frame shaft, as will be explained later on, and

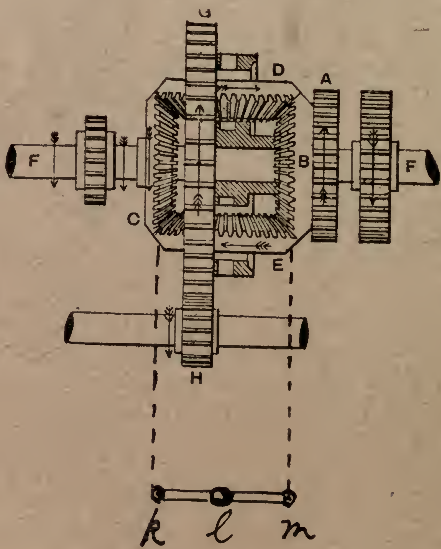


FIG. 31.

therefore the bobbins would revolve at the same speed as the spindles. It is by running the bobbins at a different speed from the spindles, however, that the winding on of the rove upon the former is effected, and it is to govern and maintain this difference in speed that the piece of epicyclic gear, known as the differential motion, or sun and planet wheels, was introduced by Houldsworth.

Besides what is practically the original Houldsworth wheel, several modifications are employed by various makers with the object of reducing friction. The first arrangement, as seen in fig. 31, consists of a large spur wheel of, say, 105 teeth, having two bevel wheels working upon studs set at right angles to its axis and placed between the latter and the rim

of the wheel. The large spur wheel, or crown wheel as it is sometimes called, revolves loosely upon the frame shaft, carrying round with it the wheel which it contains. Upon either side of it and upon the frame shaft are two bevel wheels of equal diameter and pitch to those in the differential wheel. One of these, that to the left, is fast upon the shaft. The other, to the right, is loose and compounded with the socket wheel before referred to, which drives the bobbins through link gearing or chains.

If the motion be carefully studied it will be seen that if the crown wheel be held at rest, the bevel wheels which it contains will merely serve as carriers to transmit the motion unchanged, except as regards direction to the socket wheel. With the ordinary wheel, then, the socket wheel always travels in an opposite direction to the frame shaft when at work. If the frame shaft be at rest and we turn the crown wheel by hand in the same direction as it usually turns in old jute rovings, i.e., in the opposite direction to the frame shaft, we will find that, since the two bevels upon the shaft are the same size and pitch, the loose one and socket wheel will make two revolutions for each made by the crown wheel and in the same direction, one revolution being due to the motion imparted to the intermediate bevel by being turned round the fixed bevel and the other to the crown wheel carrying round the loose bevel with it in consequence of the reaction of its teeth upon those of the intermediate bevel. The motion of the socket wheel is, then, when at work, the resultant of two velocities in opposite directions—one imparted to it by the frame shaft and the other by the crown wheel. The former is equal to that of the frame shaft, but in an opposite direction; the latter is equal to twice that of the crown wheel and in a direction opposite to the former. In other words, if the velocity of the frame shaft be called a and the velocity of the crown wheel b, the resultant velocity of the socket wheel is $a-2b$. The bobbin, then, is driven faster or slower by changing the speed of the crown wheel or its substitute by means of one of the arrangements which we will presently describe.

It is by putting the crown, jack or differential wheel in motion, then, that a difference in speed between the bobbin and flyer is obtained. This difference in speed, and consequently the speed of the crown wheel, varies inversely as the diameter of the bobbin barrel as it fills.

The bobbins revolve comparatively slowly when empty,

gradually increasing in speed as they fill. There are at least three different ways of driving the crown wheel and changing the difference in speed of the bobbin and flyer proportionate to the diameter of the bobbin. The one in most general use in the jute trade is Fairbairn's application of disc and scroll mechanism which we will presently describe in detail. Generally speaking, a friction bowl slides upon a feather upon a shaft which through gearing gives motion to the differential wheel. The bowl and the shaft upon which it slides receive motion by frictional contact with two horizontal discs upon a vertical shaft or spindle. The lower disc only is keyed upon the vertical shaft. The upper one works upon a long sleeve which carries a mitre wheel keyed upon its upper extremity. The vertical shaft and discs receive their motion through intermediate gear from the twist wheel. This motion is a regular one, and the change in speed of the crown wheel is effected by shifting the friction bowl from the periphery towards the centre of the discs by means of guide rods, a lever, and a scroll.

The method employed by the well-known firm of Messrs. Combe, Barbour, of Belfast, and also in a modified form by Messrs. Douglas Fraser, Arbroath, is by means of a special form of expansion pulley, which is usually driven from the boss roller by means of a band and which gradually increases in size as the bobbin fills, swinging upwards at the same time to adjust the tension of the band, or fixed and provided with a similarly collapsible tension pulley. One-half of the former expansion pulley is fast upon its spindle, while the other is free to move inwards and intersect the other, as it is constrained to do so by being gradually raised and at the same time pressed against a triangular slide. If it is fixed, as in its latest form, a vertical slide bar, carrying two triangular sides, one at either extremity, is permitted to descend slightly at each change of the builder and alter the diameters of the expansion pulley proper and its tension pulley. Under the older method, the expansion pulley is raised by means of a quadrant which supports one end. The angle plate which controls the intersection of the two sides of the pulley is generally made with a bevel of 1 in. per inch perpendicular. The angle of the sides of the pulley is generally such that, for every inch the pulley is pushed in its diameter is increased by $1\frac{1}{4}$ in. Each shift of the quadrant and of the pulley is effected when the builder has reached the extremity of its travel at either end, by the escapement of a ratchet wheel, the catch retaining which is released by the motion of the builder.

The speed of the bobbin and builder is thus regulated for each succeeding layer of rove.

Messrs. Lawson of Leeds, Messrs. Walker of Lille, and Messrs. Mackie, Belfast, employ a pair of cones to vary the speed of the differential wheel, and hence the speed of the bobbins. The upper cone is positively driven, and drives the lower one by means of a belt which is gradually shifted from the small end of the lower cone to the large end as the bobbins increase in diameter, thus causing the lower cone and differential wheel and builder to run more slowly towards the end of the set or doff. The slower differential wheel causes the bobbins to lose less in speed, and consequently to run almost as fast as the spindles. They must run slower than the spindles, or the rove would not be wound upon them, but their winding on diameter is so great when full that the difference in speed is not nearly so great when they are full as when they are empty.

The diameter of a properly shaped cone of which the diameter at one end is double that at the other, at any point, may be found by multiplying the length of the cone in inches by the greater diameter and dividing by the length of the cone in inches, plus the distance of the given point from the large end of the cone. Thus the diameter of the cone 6 in. by 3 in. by 36 in. at a point 10 in. from its large end is $\frac{36 \times 6}{36 + 10} = \frac{216}{46} = 4{\cdot}7$ in. The diameter of the complementary cone at a similar distance from the small end is (6 in. + 3 in.) $-$ 4·7 in. = 4·3 in. The diameters being calculated in this way, a pair of cones is produced in which the slope from the small to the large end is not a straight line, in one being slightly rounded and in the other correspondingly hollowed. This curve is what is known as a hyperbola, and is the only one with which the speed of one being constant the speed of the other, and consequently that of the crown wheel and lag or gain of the bobbin, may be increased or diminished by a given shift of belt, by amounts proportionate to the increasing diameter of the bobbin barrel.

Another method sometimes used is by means of cones. The larger diameter of the cones is usually about 6 in. and the smaller 3 in., their length being about 36 in. In a properly constructed pair of cones the slope from the small to the large end is not a straight line, in one cone being slightly concave and in the other correspondingly convex.

The diameter of a properly shaped cone of which the diameter at one end is double that at the other, at any point, may be found by multiplying the length of the cone in inches by the greater diameter and dividing by the length of the cone in inches, plus the distance of the given point from the large end of the cone. Thus the diameter of the cone 6 in. by 3 in. by 36 in. at a point 10 in. from its large end is $\frac{36 \times 6}{36 + 10} = \frac{216}{46}$ $= 4{\cdot}7$ in. The diameter of the complementary cone at a similar distance from the small end is (6 in. + 3 in.)—4·7 in. = 4·3 in. The diameters being calculated in this way, a pair of cones is produced in which the slope from the small to the large end is not a straight line, in one being slightly rounded and in the other correspondingly hollowed. This curve is what is known as a hyperbola, and is the only one with which the speed of one being constant the speed of the other, and consequently that of the crown wheel and lag or gain of the bobbin, may be increased or diminished by a given shift of belt, by amounts proportionate to the increasing diameter of the bobbin barrel.

The cones are placed horizontally, one underneath the other, their centres being distant about 36 in. The upper one has a wheel upon the extremity of its shaft, which wheel forms part of the line of intermediate gearing between the twist change wheel and the boss roller wheel. The velocity of this cone is therefore constant for any given twist wheel. Motion is communicated to the lower cone by means of a belt which can be shifted the entire length of the cones by means of a fork attached to a rack, actuated by a weight and the escapement of the index or ratchet wheel. The small end of the lower cone can be raised by means of a rack and hand wheel when it is required to shift the belt back to its starting point to commence a new set of bobbins. When working, the weight of the lower cone is sustained by the belt, thus maintaining the tension of the latter. Upon the large and fixed end of the lower cone is a small pinion which communicates the varying motion of the lower cone to the crown wheel through a small counter shaft.

As Fairbairn's arrangement is the one in most general use in the jute trade, we will, as promised, describe it more in detail.

Fig. 32 gives a diagrammatic sketch of the undergearing of the machine. The plate driving shaft wheel B may have 27

teeth and be driven, as well as the drawing roller C, from the twist pinion A on the end of the frame shaft AZ. Upon the end of the plate shaft BD is a bevel wheel D of, say, 30 teeth

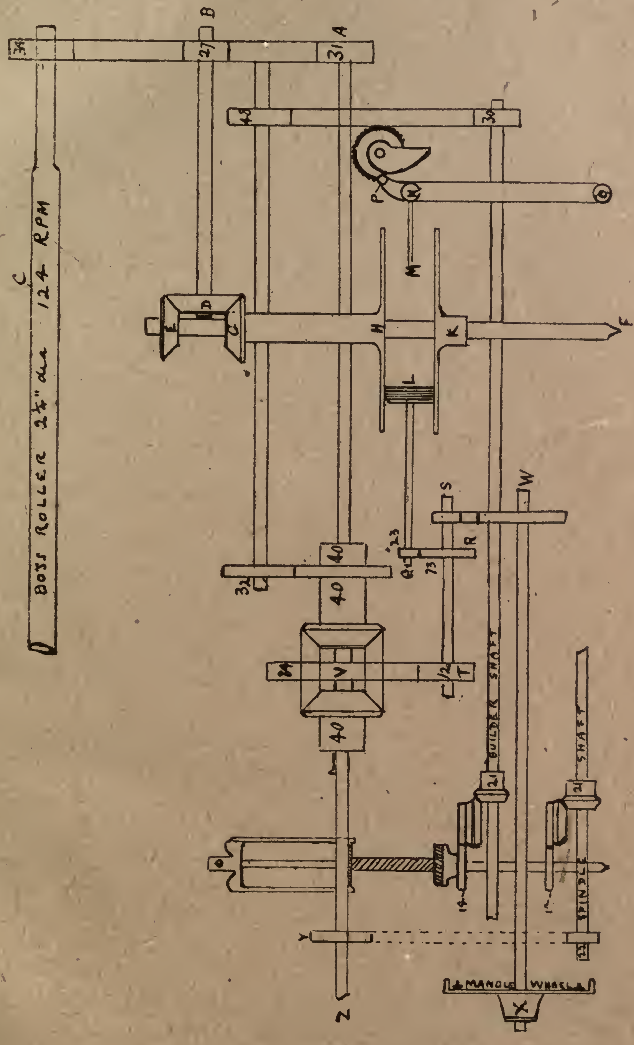


FIG 32.

driving both the vertical spindle EF and the top disc and sleeve GH, but in opposite directions. GH slides upon a feather on EF while the lower disc K is fast upon the vertical spindle and supports the friction bowl L and upper disc H which lies upon

the latter. Thus L and the shaft upon which it is keyed are driven at a speed corresponding with the position of L on the surface of the discs H and K, for it is moved from the outside of the discs towards the centre as the bobbins fill by means of the pull of the link M connected at N to a lever ONP, fulcrummed in O and pulled to the right by a weight and chain not shown. The friction roller shaft LQ slides through the pinion Q, which may have 23 teeth, and drives the wheel R of 73 teeth upon the builder and crown wheel driving shaft ST. The pinion T upon one end, which may have 12 teeth, drives the crown wheel V, which may have 84 teeth. The pinion S on the other end drives the mangle wheel shaft WX through the wheel W. The spindles are driven by the speed wheel Y of 44 teeth, the spindle shaft pinion of 22 teeth, the spindle shaft bevels of 21 teeth and the spindle pinions of 14 teeth.

A satisfactory scroll may be struck out as follows: Suppose that a 10 × 5 in. bobbin is used, with a barrel $1\frac{1}{2}$ in. in diameter. Suppose that each row or layer of rove upon the bobbin adds $\frac{1}{8}$ in. to its diameter. There will thus be $5—1\frac{1}{2} = 3\frac{1}{2} = \frac{28}{8}$, i.e., 28 layers of rove, on the full bobbin, necessitating 28 changes in speed. Calculate the working diameter of the friction plate for each change in speed. Suppose we find that the diameter at the start of the shift is 16 in. and at the finish of the shift or doff 5 in. The respective radii or distances of the boll from the centre of the disc will be one-half that distance, viz., 8 in. and $2\frac{1}{2}$ in. Draw a circle of $2\frac{1}{2}$ in. radius and another of 8 in. from the same centre. If it is desired that the scroll shall make a whole turn to accomplish its work, divide the whole circle into 28 equal parts by radial lines. It is, however, more usual to arrange that the scroll need only turn, say, three-fourths of a revolution per shift. In this case divide three-fourths of the circumference of the circle into 28 equal parts and join with the centre by radial lines. Choose the first of these radial lines at either side as the starting point and measure off from the centre a length equal to the radius of the working disc at the start of the shift. Upon the next radial line cut off a part equal to the radius of the disc when the first change takes place, and so on until the 28th radial line is reached, the point where it touches the outer circle being the end of the scroll. If all these points be joined up by a running line, the outline of the required scroll will be obtained.

The builder of the roving frame is driven up and down by means of pinions upon a builder rack shaft, these pinions gear-

ing into racks attached to the builder, which is then given a reciprocating vertical motion, being guided by vertical slides and balanced by weights supported by chains. The rack shaft is driven from the cones, expansion pulley or disc and scroll, as the case may be, so that as the bobbin increases in diameter, the motion of the builder becomes slower, so that the rove may be regularly and closely laid upon the bobbin.

There are various mechanisms actuated from the builder itself which bring about the necessary change in direction of the movement of the builder. In Combe Barbour's method a wheel upon the end of the rack shaft is driven alternately by one or other of two small pinions which gear with each other and alternately with the wheel. One of the small pinions is upon the end of a movable shaft driven from the differential motion. The other small pinion works loose upon a stud fixed in a pivoted arm which is moved backwards and forwards, putting the pinions in and out of gear by means of a connecting rod, communicating motion from a rocking piece which is turned upon its centre by the up and down motion of the builder. A quick and effective change is brought about by means of wedge-shaped pieces, the upper one forming part of a weighted lever. The apex of the upper wedge is vertically above the centre of the rocking piece, so that the latter, being symmetrically designed and turned in a negative sense by the falling builder, quickly escapes as the apices pass, and one pinion is forced into gear with the wheel, while the other is disengaged and the wheel and the builder are driven in the opposite direction.

Fairbairn, probably the largest maker of jute machinery, still uses the old mangle wheel upon the end of his rack shaft. This mangle wheel consists of a face plate, from which strong round pins project and almost encircle it. The driving pinion is upon the end of a shaft which has a little freedom in its bearings. It gears with the pin in the mangle wheel and when it arrives at the end of the row is constrained by a guide to pass round to the other side and consequently drives the mangle wheel and rack shaft in the opposite direction. This mangle wheel motion is unalterable as regards the length of traverse produced. If a different sized bobbin is to be used, the mangle wheel must be altered to suit. It would be most unusual to do this, however, as the 10 × 5 in. bobbin is in almost universal use.

Fig. 33 shows Combe Barbour's latest variation of the Houldsworth wheel.

To find the distance from the centre of the discs N and K to the centre of the face of the bowl L (fig. 30) or the radius or half the effective diameter that the disc must have when the bobbin is empty and again when the bobbin is full, we must proceed as follows:—

First find the speed of the spindles and flyers, thus:—

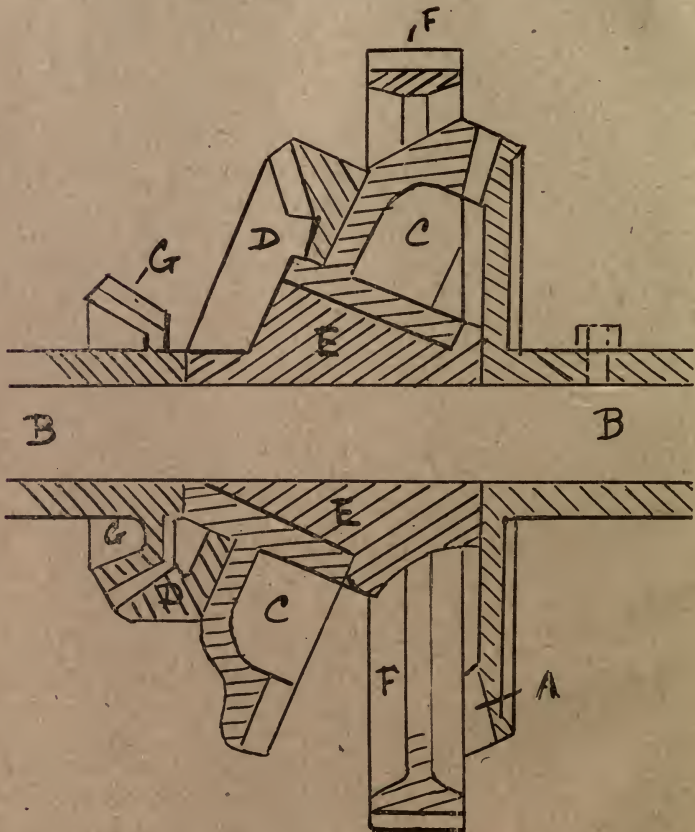


FIG. 33.—Combe's differential wheel.

Suppose that the line shaft makes 130 r.p.m. and has upon it a drum 30 in. in diameter driving the frame pulley 20 in. in diameter. The frame shaft AZ thus makes $\frac{130 \times 30}{20} =$ 195 r.p.m. Near the driving pulleys is keyed the speed wheel V (fig. 30) of 44 teeth, driving through carriers the spindle shaft pinion of 22 teeth. Upon this spindle shaft are bevels

of 21 teeth driving through bevel and spur double carrier of like teeth, the spindle pinion 14 teeth and spindle at a speed of $\frac{194 \times 44 \times 21}{22 \times 14} = 584$ r.p.m.

The delivery in inches made by the boss or drawing roller C must next be calculated. Suppose that the frame shaft which we found made 195 r.p.m. has a twist pinion of 28 teeth upon one end driving, through carriers, a boss roller wheel of 60 teeth. The speed of the latter will then be $\frac{195 \times 28}{60} = 91$ r.p.m. If this roller is $2\frac{1}{4}$ in. in diameter it delivers $91 \times 2\frac{1}{4} \times 3{\cdot}1416 = \frac{91 \times 9 \times 22}{4 \times 7} = 1{,}287$ in. per minute.

If the bare diameter of the bobbin barrel is $1\frac{1}{4}$ in. or its circumference 3·9 inches the spindles and flyers must make $\frac{1287}{3{\cdot}9} = 330$ revolutions per minute more than the bobbin in order to wind up the rove deliveries. The speed of the bobbins, therefore, at the start of the shift will be $585 - 330 = 255$ r.p.m. If the pinions compounded with the bobbin carriers have 12 teeth and gear into a spur intermediate of 20 teeth compounded with a bevel wheel of a like number of teeth gearing with a bevel wheel of 18 teeth upon the builder shaft which has on its extremity a pinion of 30 teeth driven by the socket wheel of 36 teeth through carriers, the speed of the socket wheel will then be $\frac{255 \times 12 \times 20 \times 30}{20 \times 18 \times 36} = 142$ r.p.m. nearly. To give the socket wheel this speed the speed of the differential wheel must then be $\frac{195 - 142}{2} = \frac{53}{2} = 26\frac{1}{2}$ r.p.m. If the differential wheel has 84 teeth and is given by a pinion of 12 teeth upon one end of a spindle which carries a wheel of 72 teeth at the other end driven by a pinion of 27 teeth upon the end of the spindle upon which the friction bowl slides, the speed of the latter will be $\frac{26{\cdot}5 \times 84 \times 72}{12 \times 27} = 495$ r.p.m. nearly at the start. This friction boll is driven by the friction plate

upon which it lies. As this plate is driven from the frame shaft through the twist wheel, which we will say has 30 teeth, driving a wheel of 27 teeth upon the end of the shaft which drives the friction plate, its speed is $\frac{195 \times 30}{27} = 217$ r.p.m. nearly. As the speed of the friction boll must be 495 r.p.m. the relative diameters of the boll and the circle upon which its centre lies on the plate must be in the inverse ratio. Thus, if the diameter of the boll be 5 in., the diameter of the circle on the plate upon which it rests at the start of the shift will be $\frac{495 \times 5}{217}$ = nearly $11\frac{1}{2}$ in., or the centre line of the face of the boll will be $\frac{11{\cdot}5}{2} = 5\frac{3}{4}$ in. from the centre of the disc.

The bowl is moved towards the centre of the disc with every layer of rove which is put upon the bobbin, so that the differential wheel may be driven slower and the bobbins consequently faster. As the fixed increase in diameter per traverse of the builder due to the thickness of a layer of rove is a variable proportion of the diameter of the bobbin, the amount of shift of the boll upon the plate or disc diminishes as it comes nearer to the centre or as the bobbin fills. It is by means of a scroll that this is brought about, the scroll being shaped to produce the desired result. The scroll is on the same spindle as the ratchet wheel. Connected with the boll is a shaft which moves it in and out on the disc, the end of this shaft bearing upon the face of the scroll. As the ratchet turns round, so does the scroll, and a chain and weight pulling the boll towards the scroll, the boll is drawn towards the centre of the disc as the scroll permits. To obtain the correct shift of the boll it is therefore only necessary to shape the scroll aright.

Fig. 34 illustrates the correct method of shaping the scroll of Fairbairn's roving frame as described on p. 70.

The curve thus formed (see fig. 34) is a hyperbola and regulates the movement of the lever and connecting rod M, fig. 32

In a jute roving the usual working diameter of the driving discs are from $19\frac{1}{2}$ in. to $5\frac{3}{4}$ in. for an empty bobbin barrel of $1\frac{1}{2}$ in. diameter with 5 in. head or full diameter, or $6\frac{7}{8}$ in. of traverse.

Owing to the fact that the builder of the roving frame does not remain stationary in one place, but has an up-and-down traverse, there is some difficulty in gearing up the

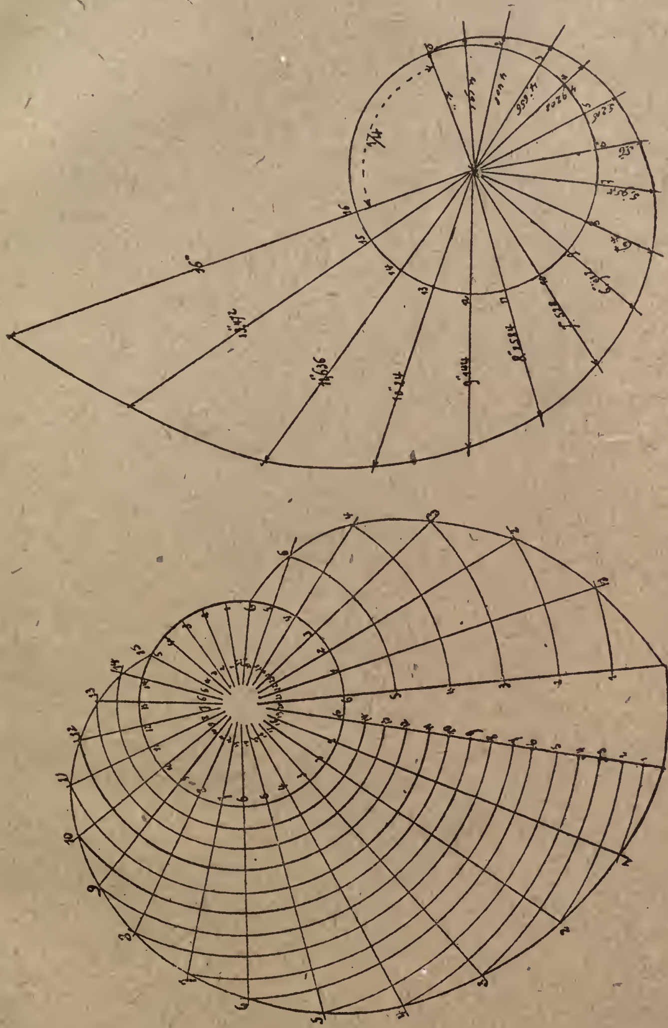


Fig. 34.

socket wheel and bobbin shaft as to counteract the unavoidable increase and decrease of speed of bobbins caused by the oscillations of the bobbin shaft wheel around the socket wheel.

Fig. 35 shows one of the best forms of link motions. The dotted lines plainly illustrate its action when the lift is

at the top and bottom of the traverse, BW being the socket wheel and W the bobbin shaft wheel.

The comparative light slivers delivered from the roving frame boss roller could not be wound upon and again unwound from the bobbin without giving it a small degree of twist to strengthen it. The amount of twist required varies from $\frac{1}{4}$ to 1 turn per inch, being directly as the square root of the yards per ounce, or inversely as the square root of the weight of unit length, or inversely as the diameter of the rove. The speed of the spindles being constant, the twist is altered by changing the speed of delivery or the velocity of the boss or delivery roller. This is done by increasing or decreasing the

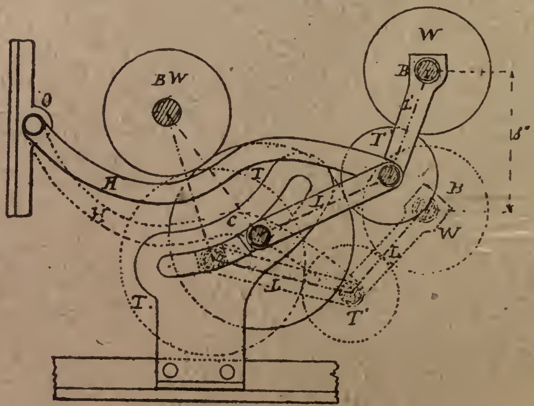


FIG. 35.

number of teeth in the twist change pinion which lies in the train of gear which communicates motion from the frame shaft to the boss roller.

In changing from one weight of rove to another, the new twist wheel may be found by squaring the number of teeth in the old twist wheel, multiplying by the number of yards per ounce in the old rove, dividing by the number of yards per ounce in the new rove, and extracting the square root of the result.

Example.—If a 48 twist pinion is required for rove 25 yards per ounce, what pinion will be required for rove 50 yards per ounce? Less, or,

$$\sqrt{\frac{48^2 \times 25}{50}} = \sqrt{\frac{2304 \times 25}{50}} = \sqrt{1152} = 34 \text{ nearly.}$$

Another method is to work by proportion, add old twist

pinion to the result and halve the sum of the two thus:

$$50:25::48:24 \text{ and } \frac{48+24}{2} = 36,$$ thus getting nearly the same result.

If, as is frequently the case in the jute trade, the weight of the rove is reckoned in drams per 100 yards, the calculation is made in a similar manner, but the twist pinion required is directly as the square root of the drams per 100 yards.

Care must be taken with some new types of roving frames, lest the twist pinion instead of being a driver is a driven pinion, when a small twist pinion would give less twist instead of more, as in the frames of other makers. In dealing with these frames, the answer to the same question would therefore be $50:25::48:96$ and $\frac{48+96}{2} = 72$, the twist pinion required. The index or ratchet wheel controls the shift of the friction bowl, the rise of the expansion pulley or the shift of the cone belt, as the case may be. It is turned by the action of a weight and chain and is allowed to escape by one-half tooth, at each rise and fall of the builder, by the raising of a pawl which holds it, by the action of the builder itself.

A change pinion lying in the train of gearing connecting the friction bowl expansion pulley or lower cone with the builder rack shaft is called the builder pinion. It should be changed when the weight of the rove is varied to any considerable extent so that the spirals of rove may be built side by side upon the barrel of the bobbin.

The index wheel must likewise be changed under like circumstances or else the rove will be built too slack or too hard upon the bobbin. The number of teeth in the index wheel should be directly proportional to the square root of the yards per ounce of rove and inversely proportional to the square root of the drams per 100 yards.

Example.—If a 35 index wheel is required for rove weighing 16 drams per 100 yards, what index wheel will be required for rove weighing 24 drams per 100 yards?

$24:16::35:28.$

An easier method and nearly accurate, is to work by proportion, add the old index to the result and halve the total thus obtained, as follows: $24:16::35:23 \; \frac{35+23}{2} = 29.$

When the "dollop" system is employed, the weight of the rove is altered by changing the clock pinion so as to spread a given weight of fibre over a greater or less length of feed sheet. If the ball feed system is adopted for the finisher card, the actual weight of a set of balls or laps required to produce rove of a given weight may be approximately ascertained as follows: Suppose that rove 24 drams per 100 yards is required and that the draft of the roving frame is 8, finishing drawing 8, 1st drawing 8, and finisher card 30; while the doublings are 4 : 2 : and 3 respectively, and the bell of the balling machine 250 yards. *Rule.*—Multiply the yards in the bell by the drafts and the number of laps per sett and divide by the product of the yards per lb. of rove and the doublings. Thus in the example given, the weight of a set of 3 laps would be $\dfrac{250 \times 8 \times 8 \times 8 \times 30 \times 3}{1066 \times 2 \times 4 \times 3} = 450$, or the average weight of each of them $\dfrac{450}{3} = 150$ lb.

The factors which modify this theoretical result are loss in weight during the process, owing to evaporation of the batching liquid and loss of dirt or stick which drops out in the finishing, carding and drawing process, shortening of the drafts by bulking and contraction of the rove by twist. The weight of the laps or balls must be increased by a percentage corresponding with the percentage of card waste made in the finishing carding, and loss in drawing and diminished by an amount corresponding with the effects of "bulking" and twist contraction.

Bulking is a shortening of the theoretical draft produced through the increased effective diameter which the passage of the sliver over the rollers gives them. As the sliver is, say, eight times heavier or thicker on the feed rollers than it is on the drawing roller, its effect is considerable, adding one thickness of sliver to the diameter of the roller.

A rotary roving frame is an old type of roving, still used by a small section of the trade to produce heavy yarns or roving, its advantage lying in its simplicity and small wear and tear, as well as in its cheapness and in the quick speed at which they may be run. The gill pins are inserted in brass sleeves, say, 3 in. in diameter by $2\frac{3}{4}$ in. face, which are fixed upon a shaft placed close up to the drawing roller.

The disadvantages of this arrangement are the impossibility of securing a short "nip" or distance from the point where the pins leave the sliver to the bite of the drawing rollers and the tendency of the gill to lap and cause irregularities in the rove if the pins be not kept sharp and well set up.

CHAPTER VIII.

GILL SPINNING.

Gill spinning frames are frequently used in the jute trade to produce heavy rove, sacking or gunny yarns from waste, butts, cuttings, &c. The frames used are generally roving frames in reality and are for this reason often called "spinning rovings" or "regulated gill spinners," the speed of the bobbins being regulated by the differential motion already described. The twist gear must of course be arranged to enable a sufficient number of turns per inch twist to be put in. Used in this way the spindles may make 1,000 r.p.m. and are of course provided with top steadiers.

Drag gill spinners are also occasionally used, the spindles being driven by tapes from pulleys on the frame shaft.

Roving frames may now be ordered to be used as gill spinners as required, the makers arranging the twist gearing so that twists up to, say, 5 turns per inch may be put in and the spindles geared so that reverse twist may be produced if desired.

Band-driven spindles have the advantage over gear-driven of being capable of higher speeds, but are liable to produce slack twisted yarn through slippage which cannot occur when the spindles are gear-driven.

When both spindles and bobbins are geared as in the regulated gill spinner a reliable tension may be produced sufficient to pull the thread through a taper tube of such diameter that the thread is thereby polished and made appreciably smoother. When the spindles are band driven, the drag necessary to cause the flyer to wind the spun yarn upon the bobbin is produced by means of applying friction to the bobbin carrier, upon which in heavy frames the bobbin rests, and with which it engages by means of a pin as in the roving frame. This friction is applied by means of wooden friction brakes, or by means of a strap attached to a weighted lever. When wooden friction blocks are applied, they are usually tightened together round the carrier by means of a thumb-screw.

When the gill spinner has tape-driven spindles, the bobbins are dragged by drag bands which bear against the grooved base of the bobbin, the motion of which they retard sufficiently to permit of the flyer winding on the yarn as spun.

Heavy jute yarn, such as 48 to 60 lb. weft yarn or up to 200 lb. rove for rope-making, is usually gill spun on a regulated gill spinner which is practically a roving frame with the twist gearing arranged to enable a sufficient number of turns per inch twist to be put in. Twist at the rate of two turns per inch for 48 lb. yarn may be used, and for other grists a number of turns in inverse proportion to the square root of the size of the yarn or pounds per spangle.

To understand this it must be remembered that in the jute trade the weight of yarn and rove is denoted in pounds avoirdupois per spangle or spyndle of 14,400 yards = 48 cuts or leas = 4 hanks; so that the greater the number of the yarn the coarser it is, the direct opposite to the Irish linen yarn system of numbering.

A gill spinning frame is in reality just a drawing frame with spindles and flyers to put twist into the attenuated slivers as they issue from the delivery roller, and bobbins upon which the rove or yarn thus produced is wound or lapped. When the frame is "regulated" or provided with a differential motion regulating the speed of the bobbins, the requisite winding on drag is given to the bobbin through the perverted use of that differential motion which in the roving frame is used to prevent the straining of the rove. A jute gill spinner is sometimes on the screw gill or push bar principle and sometimes on the rotary gill principle, both already described. Such a roving frame suitable for 40 to 60 lb. weft yarn may have 8 in. by 4 in. bobbins, while for heavier yarns up to 200 lb. a 10 in. by 5 in. bobbin or even a 12 in. by 6 in. bobbin may be used. Top steadiers or bearings should be provided for the spindle tops so that they may be run up to, say, 1,000 or 1,100 r.p.m. without undue wear and tear.

In a non-regulated gill spinner, the drag necessary to cause the flyer to wind the spun yarn upon the bobbin is usually produced by applying friction to the bobbin carrier, upon which the bobbin rests, and with which it engages by means of a pin as in the roving frame. This friction may be applied by means of wooden friction brakes or by means of a strap attached at one end to a stationary pin inserted in the builder plate and at the other to a square-necked hook passing through a square hole in the edge of the builder plate and the round end threaded and pulled through as required by means of a thumb screw. The wooden brake above referred to may be tightened up in a similar manner.

In a spiral gill spinner, the speed at which the fallers may

be run is usually the factor limiting its production, but in heavy, coarse frames or in rotaries the speed at which the spindles may be run, even when provided with top steadiers, may limit the producing power of the machine.

The degree of twist required by the coarse yarns and rove usually produced upon the jute gill spinning frame may be calculated on the basis of 8 turns per inch for 3 lb. yarn, the number of turns required by any other grist or size being obtained by multiplying this 8 by the square root of 3 and dividing by the square root of the number of the yarn to be twisted. Thus the twist required for yarn 48 lb. per spyndle at the rate of 8 turns for 3 lb. yarn is $\frac{8 \times \sqrt{3}}{\sqrt{48}} = \sqrt{\frac{64 \times 3}{48}}$ = 2 turns per inch. The square root of the yarn number is introduced into twist calculations, since the twist should vary inversely as the diameter of the yarn, and because the diameter of the yarn varies directly as the square root of the pounds per spangle.

The twist is varied upon the gill spinning frame by changing the twist pinion which increases or diminishes the speed of the delivery roller, &c., the speed of the spindles remaining constant.

For instance, the twist gearing of a gill spinning frame spinning 48 lb. yarn may be arranged to give nearly 2 turns per inch, or 24 turns per foot twist as follows:—

Upon the delivery roller, which may be 4.4 in. in circumference, there may be a wheel of 102 teeth driving the twist change pinion of 25 teeth, which may be compounded with a stud wheel of 64 teeth. A series of intermediates may communicate motion from this wheel to a wheel of 44 teeth upon the spindle shaft. If upon this shaft there are bevel wheels of 28 teeth driving into others of 19 teeth on the spindles, the turns per inch twist will be $\frac{102 \times 64 \times 28}{25 \times 44 \times 19 \times 4{\cdot}4}$ = 2 nearly.

48 lb. yarn = 1 lea yarn. Found in the other way, the twist required for this yarn is $\sqrt{1} \times 2 = 1 \times 2 = 2$ turns per inch as before.

CHAPTER IX.

DRY SPINNING.

JUTE is universally spun dry. When carded, as it usually is, a 9 in. reach suffices upon the dry spinning frames upon which sizes up to, say, 20 lb. yarn are spun.

Fig. 36 shows such a frame, while fig. 37 shows more of the details. It will be seen that the bobbins of rove RB produced upon the roving frame, are placed upon stationary pins, ranged above the feed rollers AB, the feed roller B is of steel and fluted 12 to 20 per inch in diameter, while the double bossed metal pressings A behind it are similarly fluted.

FIG 36.

The drawing roller D is likewise of steel, its bosses being from 3 to 5 in. in diameter and from $\frac{3}{4}$ in. to $1\frac{1}{8}$ in. face. The faces of the bosses of this roller are "scored" to about 16 to 24 per inch of diameter. The pressing rollers C, usually of sycamore, are from 8 to 10 in. in diameter and tapered to a narrow face, say $\frac{1}{4}$ in. broad, and are placed behind the metal drawing roller D, against which they are pressed by springs or lever pressure. In passing between the feed rollers AB and the drawing rollers CD, the rove is guided and controlled by a breastplate Z.

The length of reach being equal to that of the longest fibres, the breastplate may be made to take the place of gills in controlling the delivery of material to the drawing rollers, for the breastplate may be advanced or retired either partly or bodily by means of adjusting screws, causing the

rove which passes over it to be pressed against it with more or less tension, preventing the twist from running out of the rove and the short fibres from being "gulped." A small funnel-shaped tin conductor is used to guide the material to the narrow faced drawing roller. The spindles are in one row. Their pitch or distance apart is from 3 to 5 in. The vertical line of the spindle produced is only very slightly forward from the point of delivery, causing the end, while being twisted, to bear very slightly upon the eye of the thread-plate which steadies it and prevents "ballooning." The flyers F are screwed upon the spindle tops. The thread or yarn is lapped once or twice around the leg of the flyer and passes through a semicircular nick in its flattened or fish-tailed end to the bobbin, which runs loose upon the spindle. The bobbin used varies from 5 in. by 3 in. to 3 in. by 1½ in. The base of the bobbin is grooved for the drag-band, which, attached to the back of the builder BP, touches the bobbin base and passes over the nicked front edge of the builder, tension being maintained by a drag weight DW attached to the end of the cord. The bobbin rests upon the builder BP which is given an up and down motion by means of poker rods, chains and builder shaft, which is given a reciprocating rotary motion by means of a heart-wheel lever and connecting rod. The spindles rest in footsteps set in the step rail which extends the whole length of the frame. They run in taper brass collars set in the neck rail and are caused to revolve at a speed of from 2,000 to 4,000 revolutions per minute by tapes or lists X 1¾ in. to 2¼ in. wide by about 65 in. long, passing round a tin cylinder CY and a wharve W fast upon the spindle butt.

The type of spindle shown in fig. 37 is the flexible Bergmann spindle, which, however, is almost unknown in Dundee, where the ordinary rigid spindle with fixed neck and step rails and whorl higher up on the spindle butt is preferred.

A great saving in power in spindle driving is effected by keeping the pull of the driving band or list X horizontal and at right-angles to the spindle by the use of a supplementary tin guide cylinder, say 6 in. in diameter, placed in fixed bearings between the spindles and their driving cylinder CY. Similar results may be obtained by the use of swinging tension pulleys, pulled backwards by springs or levers and weights. Although keeping the tension of the lists uniform, they are more troublesome than the former arrangement.

A rove traverse motion for the feed rollers and a roller

traverse motion for the drawing roller should always be provided to increase the life of both sets of rollers.

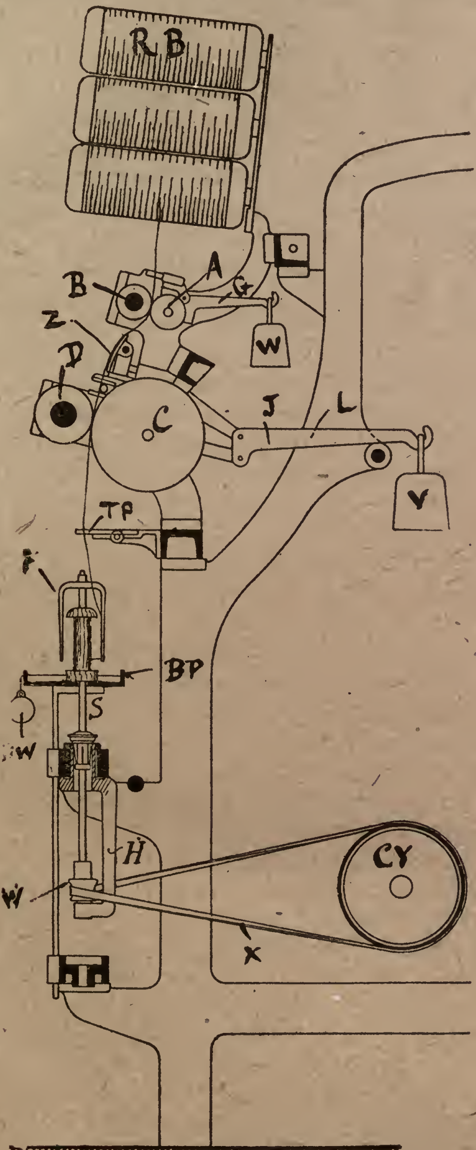


FIG. 37.—Jute spinning frame.

The feed rollers of the jute spinning frame are fluted, but the drawing roller only scratch fluted. The wooden pressing

rollers, which work in contact at the rear of the latter, require no fluting. Plane tree or sycamore wood is used for the rollers. It must be thoroughly seasoned and requires two or three years' slow drying to fit it for the work. The rollers are tapered off to a narrow edge at the periphery, just wide enough to correspond with the tin conductors which fit over them and with the size of yarn being spun. If the face is unnecessarily broad the roller becomes hollow in the middle of its face and will no longer draw properly. To counteract the hollowing tendency the face of the roller should be slightly rounded.

It is most important that the rollers should be kept in good condition for well spun yarn cannot be produced if the rollers are faulty. In order to save wood, the faces of these rollers, when they become imperfect, are scraped or filed. As a perfect face cannot be produced in this way, such methods cannot be recommended even on the ground of economy. They should be slid in pairs in a special wood roller sliding lathe, with sliding tool carrier worked by rack, pinion and hand wheel. Both bosses on the same axle are then of exactly uniform diameter.

Instead of the weighted lever JLV, shown in fig. 37, p. 85, other methods of applying pressure to the wooden pressing roller C to hold it against the roller D are sometimes used with a view to reducing the weight of the frame and risk of denting the roller faces when a roller is pressed back by a lump, the weight raised and suddenly let fall again. A steel spring or spring rod with I.R. washers are not infrequently met with as a substitute for the dead weight. On a Saturday, or before any other lengthened stoppage, the pressure should be taken off the rollers lest they become dented by constant pressure in one place. A means is sometimes provided to raise all the levers at once by turning a hand-wheel at one end of the frame when it is desired to relieve the pressure.

The flyers of the dry spinning frame are fish-tailed, i.e., the extremities of the legs are flattened and a ground groove cut out in the centre through which the thread passes to the bobbin. The thread passes from the threadplate eye between the spindle and one leg of the flyer to the leg opposite, passing round it once, and indeed sometimes twice, and goes from the inside of the leg to the outside of the palm and thence to the bobbin. This reduces the tension on the untwisted or lightly twisted portion of the thread, reduces ballooning, and does away with any necessity for a heavy drag.

Since no great bearing on the threadplate eye is therefore required, the projection of the drawing roller face behind the line of the spindle may be little or none, the thread passing downwards in an almost direct line, the threadplate merely steadying the thread.

For jute dry-spinning frames a 9-in. fixed reach is almost universal. However, since there are various qualities of material and sizes of yarn, a breastplate is required to give a controlling bearing on the rove being drawn and to hold the twist to a greater or lesser extent as required. This plate Z, fig. 37, sometimes also called the conductor plate, is movable backwards and forwards, and can be inclined to any desired degree, the top being screwed in and the bottom out or *vice versa*.

As jute roves are generally rather hard twisted for rove, only a light bearing or binding on the plate is usually necessary and that towards the top edge of the plate. Binding keeps the twist from running out and prevents short fibre being gulped into slubs leaving corresponding shires or thin places to follow. A bearing on the tin conductor rod which lies between the breast-plate and the nip of the drawing roller has a similar effect, so that the projection of this rod is also made adjustable. The tin conductors which hang upon this rod should reach as nearly as possible to the nip of the drawing roller without touching the metal roller. A draft of 7 is quite sufficient if good yarn is to be produced.

The pitch or distance apart of the spindle of jute spinning frames varies from $3\frac{1}{2}$ to 5 in., $3\frac{3}{4}$ in. being a very common Dundee frame for the production of 8 lb. cops.

Five lb. yarn is about the smallest size of carded jute yarn, and 40 lb. the heaviest spun on the dry spinning frame, say of 5 in. pitch.

The draft of a dry spinning frame may be calculated upon the same principle as that of a drawing frame, i.e., it is the ratio existing between the surface speeds of the top feed or retaining roller and of the boss or drawing roller.

Rule to find Draft.—Multiply the number of teeth in the feed roller wheel by the number of teeth in the stud wheel, and by the diameter of the bosses on the drawing roller and divide by the number of teeth in the draft change wheel, multiplied by the number of teeth in the drawing roller wheel and by the diameter of the feed or retaining roller. The constant standing number or gauge point is found by leaving out the change pinion from the calculation.

In jute yarns the size or grist is almost universally denoted by the weight per spindle or spangle, containing 4 hanks or 48 cuts or leas. For instance, 8 lb. yarn means that a spangle or spindle of 48 cuts or 4 hanks or 14,400 yards, weighs 8 lb. One lb. yarn has 48 leas or cuts = 1 spangle per lb., and is consequently under the linen yarn system 48 lea yarn. Twelve lb. yarn = $\frac{48}{12}$ = 4 lea yarn; 8 lb. yarn = $\frac{48}{8}$ = 6 lea yarn; and so on. When the weight of the rove is indicated in yards per ounce, the required spinning draft is found by multiplying the yards per ounce of rove 16 to bring it to yards per lb. The required draft is then the ratio between the yards per lb. of yarn and rove. Thus, if the rove measures 25 yards per ounce, or 25 × 16 = 400 yards per lb., and the yarn is required to weigh 8 lb. per spangle, or $\frac{14400}{8}$ = 1,800 yards per lb., the required spinning draft is then $\frac{1800}{400} = 4\frac{1}{2}$. Otherwise expressed, the draft is found by dividing the product of the yards per ounce of rove, 16, and the required weight in pounds per spangle, into 14,400, the yards per spangle. Thus taking the same details as before, the required draft is

$$\frac{14400}{25 \times 16 \times 8} = \frac{9}{2} = 4\frac{1}{2}.$$

Usually, this calculated draft must be increased by about 7 per cent. to counteract the contraction in length brought about by the twist put in. Naturally slack twisted wefts or starching warps require a slightly shorter draft than do the same size in harder twisted yarns from the same rove.

If the weight of the rove is indicated in drams per 100 yards, the required draft is found by comparing the drams per spangle of rove and yarn. Thus still taking the same details as before, 100 yards of rove will weigh 16 × 4 = 64 drams, and a spangle of rove 64 × 144 = 9,216 drams. A spangle of yarn weighs 8 × 16 × 16 = 2,048 drams. The requisite draft, making no allowance for contraction by twist, is then $\frac{9216}{2048} = 4\frac{1}{2}$.

A rule in frequent use in Dundee mills and which makes a 7 per cent. allowance for contraction by twist, consists in multiplying the weight of 100 yards of rove in drams by 0·6 and dividing the product by the pounds of spindle required. The constant 0·6 is obtained by adding 7 per cent. to $\frac{14400}{100}$, making it 154, and divided by 256 the drams per lb. If a suitable spinning draft has been determined on and it is desired to find what weight per 100 yards the rove should be the rule is inverted, the draft and pounds per spangle being multiplied together and divided by 0·6.

The turns per inch twist being put in by the dry spinning frame is found first by calculating the number of revolutions made by the spindles for one revolution of the drawing roller and then by dividing this result by the circumference of the drawing roller in inches. Otherwise expressed, divide the continued product of the number of teeth in the drawing roller wheel, the number of teeth in the stud wheel and the diameter of the tin cylinder in inches, by the continued product of the number of teeth in twist change wheel, cylinder pinion and diameter of the spindle wharve in inches and the circumference of the drawing roller in inches. The drawing roller being only scratch fluted its effective circumference is approximately the product of its diameter and 3·1416.

A gauge point, standing or constant number is found by leaving the twist pinion out of this calculation. This constant number divided by the number of teeth in any change pinion gives the turns per inch produced, and divided by the turns per inch required gives the requisite number of teeth in the twist change pinion.

It is sometimes reckoned that a good average twist for 3 lb. warp yarn is 8 turns per inch, and for 3 lb. weft 6 turns per inch, and that the turns per inch required by other sizes are inversely as the respective square roots. Thus the twist required for 4 lb. warp would be

$$\frac{8 \times \sqrt{3}}{\sqrt{4}} \quad \sqrt{\frac{64 \times 3}{4}} = \sqrt{48} = 7 \text{ nearly or approx.}$$

$$\frac{\dfrac{8 \times 3}{4} + 8}{2} = \frac{14}{2} = 7.$$

If warp yarns are to be starched they require less twist than if they are to be used unstarched. A slack twisted warp if strong enough to weave, will spread better when the cloth is calendered.

The following tables of drafts and twists may be found useful:—

Draft Table.

Showing weight in drams per 100 yards of rove required.

Grist of Yarn lbs.	Spinning Draft 4	5	6	7	8	9	10	11	12
6	42½	53½	64	74½	85½	96	106½	117½	128
7	50	62	74½	87	99½	112	124½	137	149
8	57	71	85½	99½	114	128	142	156	170½
9	64	80	96	112	128	144	160	176	192
10	71	89	105½	124½	142	160	177½	195½	213
12	85½	106½	128	149½	170½	192	213	235	256
14	99⅙	124	149	174	199	224	249	274	298
16	114	142	170½	199	228	256	284	312	341
20	142	178	213	249	284	320	355	391	426
24	170	213	256	299	341	384	426	470	512
28	199	248	299	348	398	448	498	548	596
32	228	284	341	399	456	512	568	624	682
36	256	321	384	448	513	576	639	704	768
40	284	356	426	498	568	640	710	782	852
44	312	391	469	548	625	704	781	860	938

Twist Table.

Showing turns per inch twist required by various yarns.

Grist of Yarn	Weft	Hard Warp	Starching Warp
6 lb.	4.2	6·5	5·0
7 lb.	3·8	6·0	4·49
8 lb.	3·44	5·8	4·23
9 lb.	3·1	5·25	4.0
10 lb.	2·89	4·87	3·81
12 lb.	2·58	4·3	3·65
14 lb.	2·40	3·8	3·3
16 lb.	2·19	3·7	—
20 lb.	1·90	3·4	—
24 lb.	1·68	3·2	—
28 lb.	1·6	3·0	—
32 lb.	1·5	2·9	—
36 lb.	1·4	2·8	—
40 lb.	1·3	2·7	—
44 lb.	1·2	2·6	—

In the spinning of hessian warps and wefts three sizes of bobbins are commonly used, viz., 3¾ in., 4 in. and 5 in. The 3¾ in. bobbin is used to spin from 7 to 8 warp, the 4 in. bobbin from 9 to 12 lb. and sometimes 16 lb., the 5 in. bobbin is used to spin from 16 to 24 lb. yarns. The bobbin traverse motion is produced by means of a heart, which is usually shaped in such a way that the bobbin is thickest in the centre.

The advantages of a satisfactory automatic doffing motion for jute spinning frames are obvious. They dispense with the necessity of employing gangs of young people to doff, and they increase the production of the frame by reducing the length of time the frames are kept standing for doffing the full bobbins and replacing them with empty ones.

In the latest form of automatic doffing motion for flyer frames, i.e., that made by Messrs. Fairbairns, Leeds, the cycle

of operations is as follows: By turning the handwheel (1) the full bobbins are removed from the flyers; (2) the flyer legs are adjusted and cleared of adhering coils of yarn; (3) the empty bobbins are brought beneath and into alignment with the spindles; (4) the builder is raised and other parts brought into the spinning position; and (5) after a few coils have been wound on, the threads to the filled bobbins are severed. A special mechanism is provided at the left hand extremity of the builder to temporarily shift the nicked drag band in front of the builder so as to remove the drag bands from the grooved bases of the bobbins to permit of the doffing operation. The spindles are mounted in the step rail, which alone supports the weight of the spindle and the flyers, the spindles being steadied in the action by entering bushes formed in the builder. The latter is supported by arms extending from sliding supports which are mounted upon vertical guiding rails. By connecting the supports to the wheels which are mounted on the builder wheel shaft, the builder is operated under balanced conditions. Beneath and in the rear of the builder is a bar upon which are fixed bifurcations adapted to take beneath the span the upper flanges of the empty bobbins destined to take the place of the full bobbins. The bar is supported by lever arms connected together by a rod so that they all work in unison and move the bar from its rear position to its advanced position immediately under the flyer.

When the bobbins are filled the frame is stopped in the usual way. Then the spinner or doffing mistress, after removing the coupling, turns the handwheel which is fixed upon the end of the builder shaft, rotating it in the same direction to enable the grooved pulleys to pay out sufficient of the chains to let the builder descend low enough to carry the full bobbins below the lower ends of the spindles. During the latter part of the rotation of the shaft a projection on the chain comes into contact with the end of the lever and commences to move the latter in order to move forward the empty bobbins carried on the rail. The empty bobbins thereon push the full bobbins off the builder into the box. While the rail is moving forward the bar descends so that the fingering passes over the lower ends of the spindles to remove any coils of yarn that may have slipped from the full bobbins on to the lower ends of the spindles. Prior to this spindle cleaning operation, a cam moves the bar sufficiently far forward to cause its projections to adjust the legs of the flyers in position to permit the advance of the fingers.

When the full bobbins have thus been removed, the operative turns the handwheel in the other direction in order to carry all the parts back to their normal positions. As the builder shaft is turned in the reverse direction, the builder is raised to lift the empty bobbins clear of the projections. The rail is then moved backwards and the lever returned to its normal position. The builder is further raised to carry the empty bobbin within the flyers so that the spinning operation may be recommenced. After a few coils have been wound upon the bobbin of a new set, the depending threads from the full to the new bobbins are severed by a toothed sliding cutter.

Fig. 38 shows another automatic doffing arrangement in considerable use on the Continent. It will be seen that the flyer is carried and driven from above, while the bobbins run on freely revolving short spindles mounted in a square rail which can be turned to bring fresh bobbins under the flyers. The flyer is screwed to a small hollow spindle which also carries the wharve for the band and revolves in two gun-metal bushes carried in a cast-iron double rail which runs the whole length of the machine. The bottom bush acts as a footstep bearing, while the top bush is bored to suit the taper on the upper part of the spindle and can be adjusted to take up wear. The spindle is made hollow to permit the thread to pass down the centre from the eyeboard or thread-plate to the flyer. The method of threading is to push the thread into the hole in the side of the spindle and draw it out at the top with the finger, the flyer meanwhile being held by a patent holdfast, allowing the spinner to use both hands when threading. The bobbins are mounted on hollow spindles or pins, supported by two bushes let into the square cast-iron carrying rail. This rail is turned through 90 degrees when one set of bobbins is filled, bringing a row of empty bobbins into position. While in one make of this arrangement the pins go right through the rail, in another the rows are "staggered" and the rail is given an endwise motion when revolving so as to bring fresh bobbins to the centre of the flyers. This is arranged for by suitable cams at the ends of the rail.

The method of operation is as follows: The empty bobbins are placed upon that row of pins which projects towards the spinner and the rail being given a quarter turn, these bobbins are brought under the flyers when they are filled. When full the operation is repeated, the full bobbins being turned down

towards the rear with the thread running direct to the flyer eye. When the frame is restarted and the flyer revolved, it carries the thread round the fresh bobbin and commences to

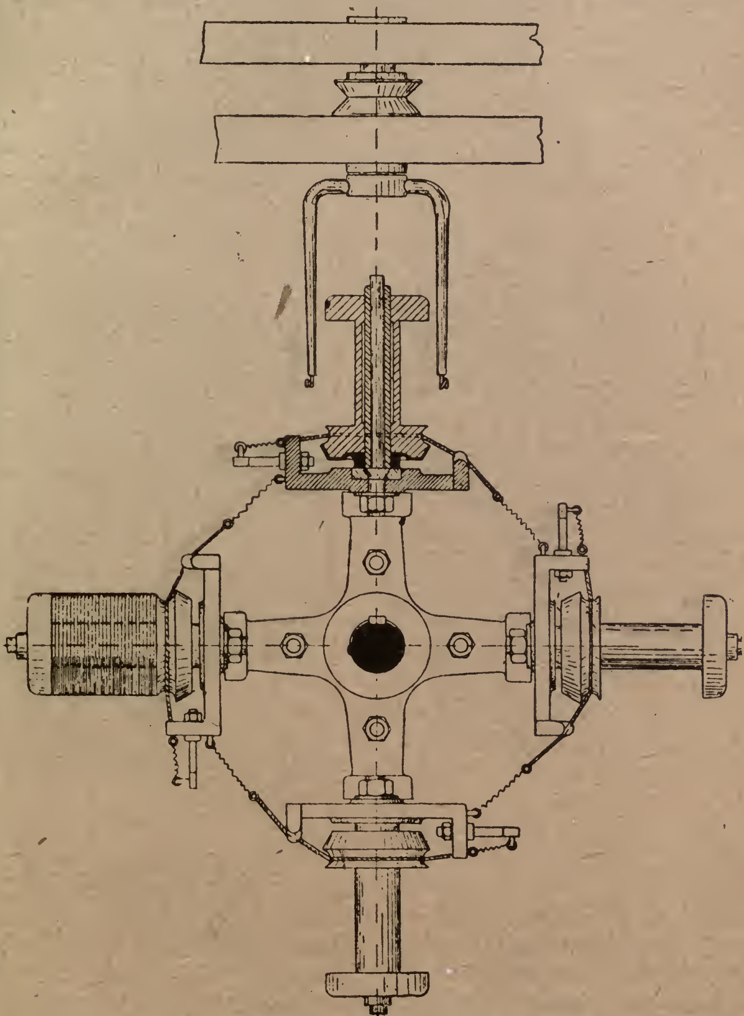


FIG 38.—Automatic doffing.

fill it. The uniting thread is then automatically cut. At the next turn of the rail, the full bobbins turn downwards, drop off the spindles and fall into a receptacle on to a conveyor band which carries them to the end of the machine. The

advantages of this arrangement are: (1) Quick doffing, with a minimum of labour; (2) doing away with a long and heavy steel spindle, which on a $3\frac{3}{4}$ in. frame, for instance, weighs about $4\frac{1}{2}$ lb. and which must be carried round at high velocity. A saving in power is thus effected.

The chief disadvantage is the difficulty of threading the flyer and piecing up.

Lawson's patent centrifugal flyer dry spinning frame, shown in figs. 39, 40 and 41, spins direct on to the bare spindle and winds up the yarn as spun into a hard cross wound roll or

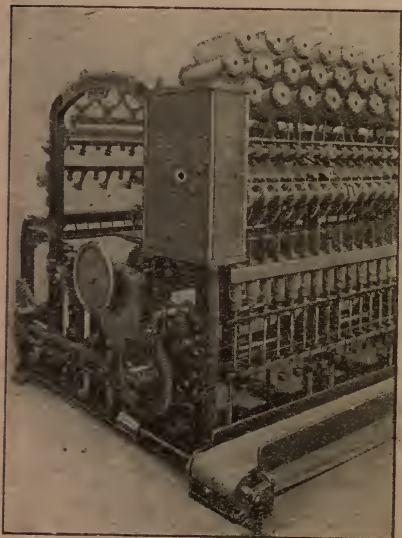


FIG. 39.

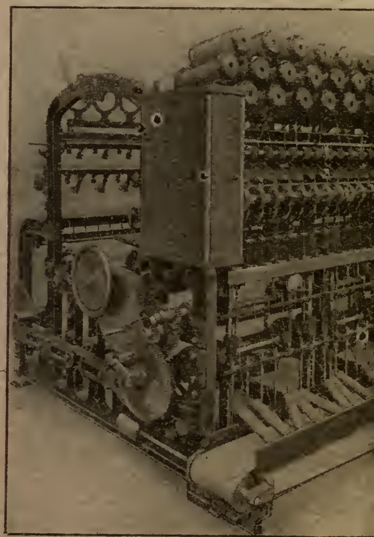


FIG. 40.

cop ready for the shuttle or the warper's bank. The hardness of the build is in part due to the swivelling centrifugal presser flyer leg pivoted close to the periphery of the revolving band-driven carrier ring and provided at the lower extremity with fish-tail guide eye, and at the upper extremity with a crank guide eye, which swivels with the presser leg. The presser leg is always lightly pressed against the surface of the yarn upon the spindle, and the fact that at no portion of the doff is there any space between the point where the yarn leaves the strain, taking up support of the presser leg, and the bobbin has a great deal to say to the absence of breakages due to the higher speeds attainable with this

frame. The spindle is dragged round by the pull of the yarn and is dragged by means of a drag band partly encircling a drag band wharve or pulley upon the spindle itself. When starting to wind upon the bare spindle the guide eye at the top of the presser leg is approximately in a radial line extending from spindle to ring, but as the cop increases in size and the fish-tail end of the presser is forced away from the centre by the accumulation of yarn, this guide eye approaches a position approximately at right-angles to this radial line. The pressure exerted by the presser is thus automatically increased as the cop increases in diameter and weight and this pressure so effectually prevents any tendency of the spindle and cop to overrun the flyer that the drag bands require little or no tempering during the progress of the doff. The ring and flyer rail is stationary, it being the spindle rails which are raised and lowered by a patent quick traverse motion at the rate of nearly 20 ft. per minute. The flyer carrier ring is easily stopped and released by a catch leaving the spinner's two hands free for piecing up. An automatic doffing motion is provided, the cops being held up by the collar rail while the spindles are withdrawn, when they are left standing upon the collars to be immediately knocked down by a rod which comes forward at the right moment, into a box placed to receive them. The spinner then winds up the step rail and spindles into their original positions, cuts the ends and puts on the frame, when the loose ends are wound upon the spindles, the ends projecting conveniently, as in the shuttle the cops are unwound from the inside. Carried out in this way doffing only occupies about 30 seconds. It is claimed that the production of the frame is at least 10 per cent. in excess of that of the ordinary dry spinning frame.

Fig. 41 gives an end section, figs. 42 and 43 show details of the driven ring flyer leg and presser, and fig. 41 details of the builder motion.

This machine is the newest in jute spinning machinery. In fig. 41, A are the feed rollers, below which are the drawing rollers. B is the revolving ring driven by a band from the tin cylinder Z passing over the guide roller Y. *b* is the centrifugal presser, C the spindle, D the vertically reciprocating spindle rail which is raised by vertical racks E, gearing with rack wheels *e*, placed at intervals on the lifting shaft *f* of the machine. On one end of the lifting shaft F a second rack wheel G is affixed with which a reciprocating sliding rack H gears to give a reciprocating rotary movement to the

lifting shaft F. The reciprocating sliding rack H is placed horizontally and is mounted in guides *h* in the framing at one end of the machine. The teeth of the reciprocating sliding rack H gear with the rack wheel G on the lifting shaft F. To the reciprocating rack H two runners $h1$ and $h2$ are fitted on studs $h3$ secured to the rack. The lifting cam K is mounted to rotate between the two runners $h1$ and

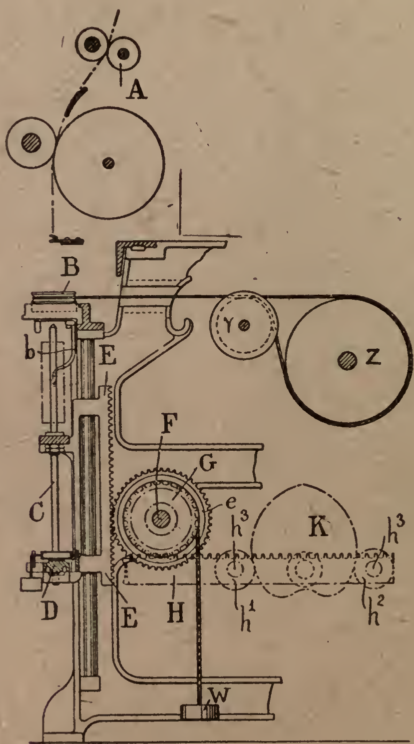


FIG. 41.

$h2$ and is in contact with both to impart movement to the rack H, first in one direction and then in the reverse direction. By this means a double acting movement is imparted to the rack and by it to the spindles, which is sensitive and positive in both directions. The cam K is driven at a suitable speed from the front delivery roller of the machine by a gear wheel K, fig. 41. It is of heart or other shape to give a similar

movement to the rack H in both directions, and shaped to prevent a dwell of the rack at either end. The runners *h*1 and *h*2 with which the cam makes contact are mounted on studs *h*3, which are readily adjusted to maintain them in close contact with the periphery of the cam.

Balance weights W, fig. 41, are suspended from the lifter shaft to about counterbalance the weights of the spindle rail.

By this arrangement it is possible to impart to the builder rails a long lift and to drive the same at a quick speed up and down, so as to produce a cross-wound bobbin and one

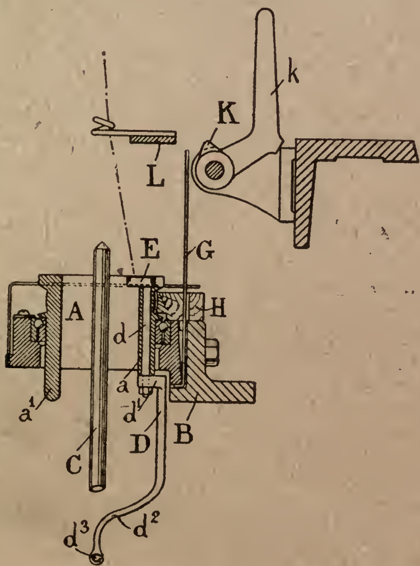


FIG. 42.

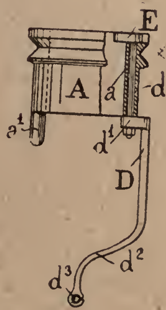


FIG. 43.

which may be spun on the bare spindle, on paper tubes or on wooden pins.

The revolving ring A, figs. 42 and 43, is mounted to rotate on ball-bearings in the ring rail B. The interior of the ring A is of a diameter to allow the cop or bobbin on the spindle C to pass through it. Internally at one side of the revolving ring A, a bearing *a* is provided in the form of a sleeve into which is fitted the upper member *d* of the flyer D.

The presser flyer D is constructed of four members, a pin *d* to fit into the bearings *a*, a cranked central member *d*1, and a presser leg *d*2 with a guide eye *d*3 at its lower extremity,

and a thread guide E to direct the yarn to the interior of the revolving ring A.

Or the presser flyer may be in one piece, forged or bent to shape, but it is preferable to build it in at least two separate parts, the pin *d*, to rotate in the bearing the swivelling presser leg *d*2 with the crank *d*1 affixed to the lower end of the pin *d* and the guide E in one piece with the pin *d*. The cranked member D1 is caused by the centrifugal motion to fly outwards and cause the presser eye *d*3 to rest against the surface of the cop or bobbin on the spindle C. The thread guide E at the top of the pin *d* is in the form of a small crank with a slotted eye *e* eccentric to the pin *d* and so positioned that the drag or pull of the yarn upon it tends to swivel the presser legs *d*2 inward and force the eye *d*3 against the spindle C or cop thereon. The guide E swivels outwards during the building of the cop and the pressure of the presser end is helped by the pull of the yarn, being least when the cop is small and greatest when the cop is full. The rotation of the revolving ring A causes the presser leg *d*2 of the presser flyer D to be swivelled so that the guide eye *d*3 at the free end is pressed into contact with the spindle C or bare tube at the commencement of the cop, and as the cop increases in diameter the guide eye *d*3 swivels away from the centre but always remains pressed in contact with the cop.

To ensure steady running of the revolving ring A, the weight of the presser flyer leg is balanced by means of a short counter-weight *a*1, fig. 42, or thick "dummy" flyer leg fixed to the revolving ring opposite to the presser flyer leg.

To the ring rail B a spring lever G is pivoted, carrying a brake block H to bear against the periphery of the revolving ring A. The spring lever is extended in an upward direction, and its upper end engages with an eccentric crank or cam K by which it can be forced forward to bring the brake block into action. The eccentric or cam K is connected to a handle or cranked lever *k* extending above the thread board L by which the brake is put on or off as required to stop or start the rotation of the revolving ring A.

In other respects the spindle C and spindle apparatus is mounted in the ordinary way with a lifting rail and a drag cord and weight.

The hand wheel by means of which the spindle rails and rack are brought down to withdraw the spindles from the cops for doffing is also seen in figs. 39 and 40.

As in the gill spinning frame with fish-tail flyers, the

bobbins of the ordinary jute dry spinning frame are dragged by means of dragbands which are attached to the back of the builder, touch the base of the bobbins, and pass over a nicked builder strip, the tension being maintained by a dragweight atached to the free end of the band. The drag upon the

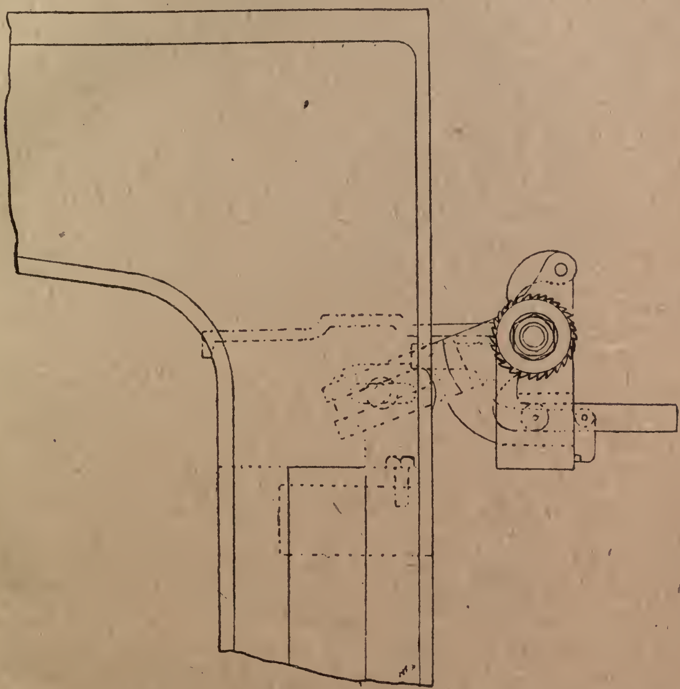


FIG. 44.

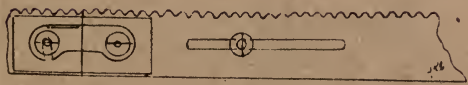


FIG. 45.

bobbins is increased by shifting the bands further along upon the nicked front builder strip and in this way causing them to embrace a larger part of the base of the bobbin. This tensioning or tempering of the drags requires some skill and

must be done regularly and uniformly as the bobbins fill and become heavier and as the pull of the thread becomes more effective through acting upon the end of a longer radial line.

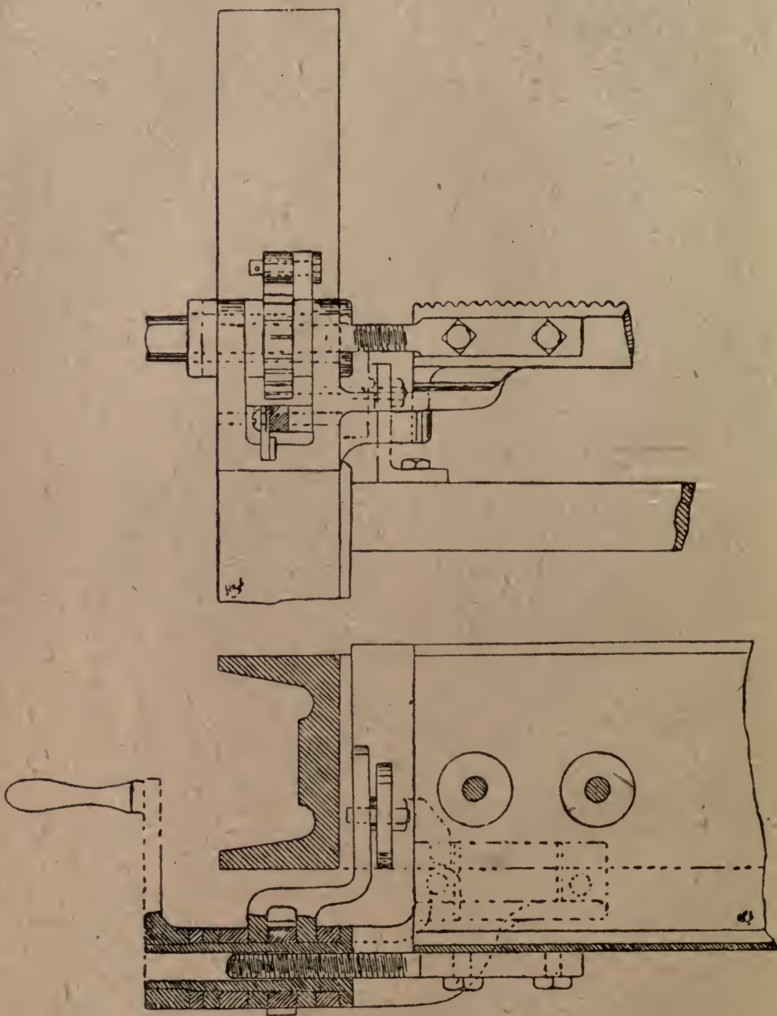


Fig. 46.

When the bobbins are to be doffed the drag bands must be set back out of contact with the bobbin bases and replaced in light contact with them when the frame is started.

The illustration herewith shows a mechanical arrangement whereby this work is done automatically and with regularity. It will be seen that the upward motion of the builder is utilized to move round, by means of a ratchet and pawl, an internally threaded sleeve, which forms a nut working upon a screw attached to the front builder strip. The front nicked builder strip is made movable while the screwed sleeve turns in a bracket attached to the builder, which bracket keeps it in position, so that in turning automatically it draws the nicked strip from right to left. As the builder falls the pawl slips over as many teeth of the ratchet wheel as it will move forward upon the return journey, the ratchet being kept from turning back the while by the lower catch shown. The pawl may be caused to move forward more or less teeth each time by shifting backwards or forwards the stud which is carried in a slotted bracket attached to the neck rail and which works in an open-ended slot in the swinging arm which actuates the pawl. Thus for every two layers of yarn which is put upon the bobbin, the drag is slightly increased so that the tension of the end remains practically regular from start to finish of the "doff" or "shift" without any attention on the part of the spinner. The result is that there is no ballooning of the ends, that the yarn is built harder upon the bobbin, which consequently contains more yarn, and that the yarn is rounder and stronger, since the fibres lie closer together in consequence of having been twisted together under tension. The handle shown is provided to turn back the screwed sleeve and in so doing to carry back the nicked strip and put the drag bands out of contact with the bobbins for doffing. The handle is also used to wind the nicked strip forward again and bring the bands into contact with the bobbins before starting the frame with a fresh set of bobbins.

A further improvement in connection with automatic drag motions such as just described, consists in automatically raising the point of attachment of the drag cord at the back of the builder as the bobbin fills, with a view to paying out the increased length of drag cord rendered necessary by the shifting forward of the nicked strip and the increased arc of the bobbin base surrounded. Without this improvement the band is worn by friction on the nicked strip and more wear and tear is put upon the shifting mechanism.

CHAPTER X.

YARN DEPARTMENT.

Scotch Jute Yarn Table.

Yards	Threads	Cuts	Heers	Hanks	Hesps	Spangle
$2\frac{1}{2}$	1	0	0	0	0	0
300	120	1	0	0	0	0
600	240	2	1	0	0	0
3,600	1,440	12	6	1	0	0
7,200	2,880	24	12	2	1	0
14,400	5,760	48	24	4	2	1

The metric system sometimes used on the Continent is arranged as follows:—

No. 1 = 1,000	metres	per	kilo.	or	1,000 grammes
No. 2 = 2,000	,,	,,	,,		,,
No. 3 = 3,000	,,	,,	,,		,,
and so on.					

The metric number multiplied by 5 and divided by 4 gives the pounds per spangle.

In Holland, the fineness of jute yarn is given by a number denoting the number of hectogrammes of 22 lb. each in 150 metres.

Cuts, heers and hanks are wound upon a reel from the spinning bobbin. The reel is usually made double with about 24 bobbins a side, the pitch of the pins which carry them being usually 6 in. The swift is made collapsible so that the hanks may be removed. The shifter, which carries the bobbins of yarn upon brass sockets turning freely on pins, has a very slow traverse of, say, 5 in., so that the threads may be wound side by side into cuts or hanks. The circumference of the swift is, of course, 90 in., to give the $2\frac{1}{2}$ yard thread. As shown by the table on page 102, a cut has 120 threads, 2 cuts make one heer, 6 heers one hank, and 4 hanks one spangle or spyndle. There is a bell motion which rings when each cut is complete. The reeler then puts in her leasing, which keeps each cut separate. The swift of the reel is turned by means of a friction plate sliding upon a feather upon the end of the swift axle and pressed by means of a footboard and levers against another fast friction plate, or against a leather friction pulley fixed upon a short countershaft, turned by a pulley and belt from the line shaft. When

the plate-to-plate drive is adopted, the sleeve carrying the driving plate is turned by screw or bevel gear from the short countershaft above referred to, or else driven by an endless ½-in. cotton rope from the line shaft.

The centre of the swift of the reel should be about 20 in. from the ground. The shifter or bobbin carrier, which extends the length of the reel, say 12 ft. or more, should lie close to the top of the swift projecting backwards from the centre line. The swift should be well balanced, so that it will remain at rest in any position and never turn back of its own accord. The periphery of the swift should be as nearly circular as possible, this result being attained by having a sufficient number of rails and spokes, usually twelve, in a Fairbairn reel. If the swift has a less number of spokes than named the segments formed between the rails will be too great and will cause the yarn to be drawn irregularly from the bobbin and subject it to jerks and strains, causing excessive breakages. If, on the other hand, the rails are too close together, they are liable to injure the fingers of the reeler and retard her progress when putting in the leasing.

Since the bulking of the threads upon the swift increases its effective circumference and consequently the length of the thread the actual circumference of the reel may be made rather less than 90 in., say ⅛ in. When the reel or swift has been filled, an arrangement is provided to make part of the swift or barrel collapse so that the hanks of yarn may all be drawn to one end for removal. A very convenient way of making the swift collapsible is that employed by Messrs. Stephen Cotton and Co., and may be described as follows:—

A flange screwed to one pair of spokes is firmly secured by set screws to the hollow barrel upon which the swift is built. The others may be freely moved round upon their axle or barrel. The swift is distended while at work, and the rails kept in place and at equal pitches by means of tapes attached to the inside of each and to the fixed rail by means of a ring and a screw. When the yarn is tightly lapped round the swift, the latter could not be conveniently caused to collapse were not one set of spokes arranged in such a way that they may be shortened and the rail at each end brought in towards the centre and the yarn sufficiently slackened to admit of the other rails being brought together. In order that the rail may be brought in towards the centre in the way we have described, it is either attached to slotted brackets clamped to the spokes by means of thumb screws,

or else to a bracket turning upon a pivot on the shortened end of the spokes. The swift turns upon ends shrunk in the barrel and revolves in closed bearings, one of which is a half-moon which may be turned by hand in a semi-circular groove, in order that the yarn may be passed round the centre, after the swift has been collapsed and the hanks rolled up and drawn to that end. In this way the endless hanks are got round the end of the swift as it sits in its bearings and removed to be bundled.

It is of much importance that the "tell" or number of threads and yards in the "cut" should be correct. For this reason a bell mechanism is provided and a bell caused to ring when each cut is complete. Messrs. Cotton's bell mechanism may be thus described: Upon the other end of the swift axle to that at which the yarn is usually taken off, is a worm, working into a bell wheel upon a vertical spindle. A pin in the bell wheel presses back a spring, upon the end of which is a brass bell which is thus caused to sound at each revolution of the bell wheel. Theoretically, the bell wheel should have 120 teeth, but in order to make up for any short count caused by broken threads, a few extra teeth are added, say 5 teeth for 7 to 9 lb. yarn and 3 teeth for 10 to 20 lb. yarn. The worm upon the axle end is single threaded, so that every time the swift completes 120 or more revolutions the bell rings, showing that a cut of yarn has been reeled.

Seven to 12 lb. yarn is usually taken off in hanks of six cuts each; 13/24 lb. yarn in hanks of 4 cuts, and 25/32 lb. yarn in hanks of three cuts each.

The bobbin carrier or shifter is actuated by the rotation of the upright spindle carrying the bell wheel, which gives it the lateral motion necessary to spread and build the yarn properly upon the swift through another worm, worm wheel, spur pinion, and rack. The shifter is of wood, about 6 in. in breadth, and rather shorter than the swift. It has two cast-iron ends, upon which it slides in the gables of the reel. The inside of one end-piece forms a rack into which the shifter pinion works. Upon the elongated pap of this pinion is a worm wheel, actuated by the worm upon the upper end of the bell-wheel spindle already alluded to. Starting close up against the gable of the machine, the shifter is thus moved either to the right or to the left, a distance of 4 or 5 in., while the bell wheel makes from three to six revolutions, according to the coarseness of the yarn being wound. After each hank has been completed, the shifter must be lifted

out of gear and put back into its starting position to the right or left. The traverse given to the shifter must be rather less than the pitch of the bobbins in order that there may be a small space beween the completed hanks.

The correct shifting of the bobbin board or shifter is essential to the best work so that the yarn in each cut may be properly and evenly spread and not built up too much in one place. In this way the threads are of more uniform length, are more easily spread out for drying after bleaching or dyeing and will wind better afterwards.

The reel swift may make about 70 revolutions per minute, but much depends upon the quality and strength of the yarn. The speed may be altered by changing the diameter of the driving pulley or by shifting the friction bowl upon its disc. Weak yarns may be reeled to the greatest advantage by having the length of yarn between the bobbin and the point where the thread first touches the swift as short as possible, in order to reduce breakages to a minimum and by keeping the pins, upon which the bobbin sockets turn, well oiled.

In starting up a reel, the first operation of the reeler is to place a number of full bobbins of yarn ready to hand before her in the box or creel/which separates her from her comrade opposite. She may then place a bobbin upon each spindle or socket and bring the ends, four or six at a time, through their respective guides and attach them to one rail of the swift, which she has previously distended to its full circumference. Having seen that both bell and shifter are in their starting positions, she may then put the swift in motion by pressing her foot upon the foot-board. She must, while finding the ends and preparing fresh bobbins, keep a good look out for a broken end or an empty bobbin and when such occur stop the reel immediately, replace the bobbin, find the end, and unite it with that upon the swift. She must find this latter, as when a bad reeler breaks a whole thread and joins it up or puts her end between the hank and the rail without knotting the ends together, she adds to the labour of the winder and perpetuates the faults of cross reeling and broken threads of which the winder reasonably complains. When the first cut is completed the reeler cuts off the starting ends which she tied to the rail of the swift and ties each of them in two loops round their respective cuts, drawing the latter at the same time slightly to one side at that place, in order to leave a small space between it and the following cut, which she then proceeds to reel in a

similar manner. When the bell rings for the second cut, the reeler must first see that all the ends are whole and then commence to put in the "leasing," a fine twine which is cut into lengths about two and a half times as long as the breadth of a completed hank, or, say, approximately 14 in. The middle portion of the short length of leas band is placed round the first cut, the ends crossed and placed round the second cut, then crossed again and doubled into the threads upon the swift ready to hand to continue the operation when the third and following cuts are completed.

When the last cut is finished, the two free ends of the leas-band are made into a knot, along with the end of the yarn and all cut off short. The leas-band must not be tightened up too much, confining the cuts too closely together, as in this case if the yarn is to be bleached or dyed, difficulty will be experienced in obtaining good results, as the chemicals or colouring matter will be unable to penetrate between the threads where they are closely held together by too tight leasing.

The reel being finished, the swift may be collapsed, and the hanks of yarn removed in one or more bouts, each of which should bear a ticket giving the number of the frame, yarn and reeler.

The object of leasing is to maintain each cut separate in order that they may be easily counted and the broken threads easily found in winding. The reeler should make the weavers' knot in joining her ends because it is comparatively small and flat and will pass more easily through the eyes of the healds and reed in weaving than other knots, some of which are also liable to slip.

The weavers', or intersecting loop knot is made by holding an end in either hand, crossing then the left under the right, passing the long end in the right hand round the back of its own extremity and in front of that of the end held in the left hand, forming a loop which is held in place between the first finger and thumb of the left hand until the short end of the thread held by that hand is passed backwards through it and held under the thumb while the loop is drawn tight, forming a fast knot.

The faults to be avoided in reeling are: (1) short count; (2) over count; (3) double cuts; (4) loose ends and crossed threads; (5) bad knots. Short count is produced by allowing the reel to run on when an end has broken or run out. Over count is usually given by continuing the last cut after

the bell has rung, with the object of making up for short count in the previous cuts, or else by double cuts counted as single cuts. Double cuts are produced when the reeler fails to hear the ringing of the bell on the completion of a cut and does not lease up until the bell rings for the following cut. Odd hanks of yarn should be counted regularly, to prevent the reeler giving too many threads under or over count and to detect and punish double cuts and faulty reeling. Loose ends often consist of cuttings which the reeler has failed to throw on the ground when knotting ends and which have become mixed with the yarn upon the reel.

Chain leasing is a method of leasing sometimes employed to provide bands of suitable size for use as bands in bundling the yarn. It consists in tying two knots, about ½ in. apart, upon the leas-band, say between the second and third cuts. The hank is thus easily separated into small parts, when such are required, by cutting the leas-band between the knots referred to.

Bundling Reeled Yarn.—Hanks of jute yarn are usually stood bunched into bundles, approximately 56 lb. in weight. In bunching from 7 to 12 lb. yarn, every two hanks are twisted together into a head and from 10 to 16 of these heads form the bundle which is tied by four half-hanks kept out of the heads for that purpose.

Thus 7 lb. yarn is usually made into a bundle weighing 56 lb. and containing 8 spyndles; 8 lb. yarn into bundles of 56 lb. and containing 7 spyndles; 9 lb. yarn into bundles weighing 54 lb. and containing 6 spyndles; bundles of 9½ lb. yarn usually weigh 57 lb. and contain 6 spyndles; 10 lb. yarn may be made into bundles of 6 spyndles and weighing 60 lb.; bundles of 11-lb. yarn may weigh 55 lb. and contain 5 spyndles; while bundles of 12 lb. yarn may weigh 60 lb. and contain 5 spyndles.

In bundling 13, 14 and 15 lb. yarn the heads usually contain 16 cuts each and 12 heads form the bundle, the weight is consequently 52 lb. for 13 lb. yarn, 56 lb. for 14 lb. yarn, and 60 lb. for 15 lb. yarn. Bundles of 15½ lb. yarn may contain 3¾ spyndles weighing 58⅛ lb. and be made of 15 heads of 12 cuts each.

Bundles of 16 lb. yarn may contain 3½ spyndles, weigh 56 lb. and be made up of 14 heads of 12 cuts each.

Made up in the same way a bundle of 17 lb. yarn will weigh 59½ lb.

Bundles of 18 lb. yarn may contain 3 spyndles, weigh 54 lb., and be made up of 12 heads, 12 cuts each.

Made up in the same way, a bundle of 19 lb. yarn will weigh 57 lb., and bundles of 20 lb. yarn 60 lb.

Bundles of 21 lb. yarn may contain $2\frac{3}{4}$ spyndles or 11 heads of 12 cuts each and weigh $57\frac{3}{4}$ lb.

Bundles of 22 lb. yarn may contain $2\frac{1}{2}$ spyndles or 10 heads of 12 cuts each and weigh 55 lb.

Made up in the same way, a bundle of 24 lb. yarn will weigh 60 lb.

Other coarser yarns may be made up into bundles containing one-half the spyndles and the same number of heads and weight as yarns half their grist.

Jute yarn is bundled up according to its size or grist in heers, cuts or half-cuts. Yarn intended for bleaching or dyeing should be based as follows:—

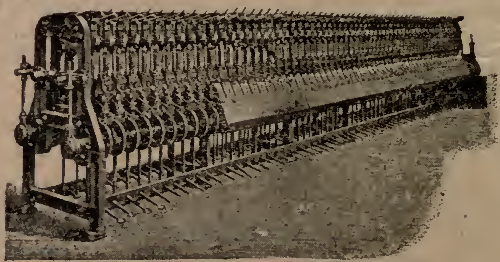


FIG. 47.—Cop winder.

Fine yarn up to 5 lb., 6 heers in the band; 5 to 10 lb. yarn, 6 cuts in the band; 11 to 24 lb. yarn, 4 cuts in the band; 26 to 36 lb. yarn, 3 cuts in the band; over 36 lb. yarn, $4\frac{1}{2}$ cuts in the band. As we have said—a bunch or "lump" weighs approximately 56 lb.

Cop Winding.—Jute yarn intended for use as weft in its natural or grey colour is cop wound from the spinning bobbin into a form in which it may be directly used by the weaver in the shuttle without further preparation.

There are several makes of cop machines, each of which accomplishes the same results in slightly different ways. All wind the yarn upon a bare spindle into a hard cop with rounded base, parallel sides and conical nose. When withdrawn from the spindle the build is such that the cop will stand a considerable amount of knocking about without breaking, and is unwound from the inside by pulling upon the starting thread which projects from the base of the cop. Generally speaking, a cop is built upon a bare spindle by means of a fixed split cup and a thread guide with a quick

and short traverse motion, almost equal to the height of the cup. The spindle is pressed into the cup in different ways, in some machines being pulled vertically downwards, in others pushed vertically upwards, while in others the spindle lies almost horizontal, in all cases being actuated by weights and levers.

In the machine as made by Charles Parker, Sons and Co., the spindles are vertical and carried in brushes or collars set in two rails which extend the length of the machine and rest on footsteps swivelling on a pin in a foot lever, the fulcrum of which is a slot in the back rail through which the far end of the lever passes. The spindles are driven by skew bevel wheels upon a shaft which runs the length of the machine. They engage with bevel pinions running loose upon the spindles and resting on the bottom neck rail. These pinions can only turn the spindles when a friction clutch, in the form of a loose collar with an internal feather sliding up and down a long keybed which extends the entire length of the round part of the spindle, is forced down upon them by means of a clutch fork, rod and clutch lever. When this latter lever is depressed, the spindle clutch grips and the spindle turns, and when the clutch lever is raised the spindle stops. An automatic stop motion is arranged so that the lever is raised when the cop has attained its proper length or when a thread runs slack or breaks. The full cop stop motion is actuated by the drawing up of the foot lever with the spindle as the cop fills. At a given point, adjustable as desired, it comes in contact with a collar upon a rod forming part of the stop motion. When a full cop has been removed, the spindle falls by gravity to its lowest position, and having been put in motion again by the depression of the friction clutch lever and the yarn given a lap upon it the fresh cop is started by the yarn traverse guide. When the accumulation of yarn upon the spindle reaches the smallest diameter of the conical cup into which the nose of the cop is pressed, the spindle is pushed upwards, a button screwed upon the spindle top preventing the cop from being pressed off the spindle end.

A stop motion is also provided to stop the spindle when the yarn is exhausted on the spinning bobbin or breaks or when it runs slack. The lower ends of the spindles are turned into the form of a ball or knob which fits into a split bush resting in the footstep and held there by means of a set screw. The thread upon the spindle top is a left-hand

one, so that the brass cap may keep on and not twist off when at work, for the spindles usually rotate clockwise. The spinning bobbins run on bare pins or preferably on brass sockets to reduce friction. The guide finger yarn traverse is actuated by an eccentric on the main shaft. The usual spindle speed is about 900 r.p.m. The guide yarn finger must always take the yarn to the bottom of the slot in the cone, independent of the diameter of the cop being made which depends upon the height to which the traverse finger rises, the diameter of the finished cop corresponding with the inside diameter of the cone at the highest point to which the thread guide rises.

In the jute cop machine, as made by Messrs. Combe, Barbour, Belfast, the nose of the cop and spindle are pressed upwards into the cop cone, instead of downwards as in Parker's machine already described. This is done by means of weights and chains passing round guide pulleys, the downward pull of the weights produced by gravity being thus changed to an upward pull or push upon the spindle foot enclosed in a spherical brass bush. The spindle used to produce the usual 9 × 1½ in. cop is about 32½ in. long.

Although not a favourite machine with Dundee hands, this machine works well, and the hands can get accustomed to any machine.

The cops when finished are put into bags if for export or into cop pans if to be used in the mill's weaving shed. To avoid broken cops it is essential that the pan or bag be the exact breadth of the length of the cop, i.e., 9 or 10 in. The length of the cop pan may well be 16 in. and its depth 11 in. Cop bags 22 in. by 10 in. by 22 in. deep should hold half cwt. of cops.

A cop machine attendant minds about 18 spindles and should make less than ½ per cent. of waste while winding, say, 60 spangles of 8 lb. yarn per ten hours' day.

In Messrs. Douglas Fraser's cop winder, as shown in the illustration, the cops are built downwards, the conical ends being uppermost and the mechanism is so arranged that the winding is always finished at the point of the spindle, thus ensuring that the cops produced, irrespective of the length, have the smaller possible holes through their centres, the spindle upon which they are built being tapered and square.

The diameter of the cop may be varied from 1⅛ in. to 2 in., being regulated by the throw of the eccentric—of which two different sizes are provided—and by the position of the yarn

traverse in the cone which is easily adjusted. The length of the cop is determined by rails, fitted with adjusting screws, each rail controlling the stop motions of all the spindles in a section. Provision is also made for individual adjustment, sometimes necessary on account of wear.

The spindles are driven through skew bevel gear by a double pawed helical surface clutch.

The pedals which carry the feet of the spindles are light, slide in guide rails and are provided with central oil wells and white metal bushes for the spindle ends. The spindles are pushed upwards by means of counter-balance chains and weights.

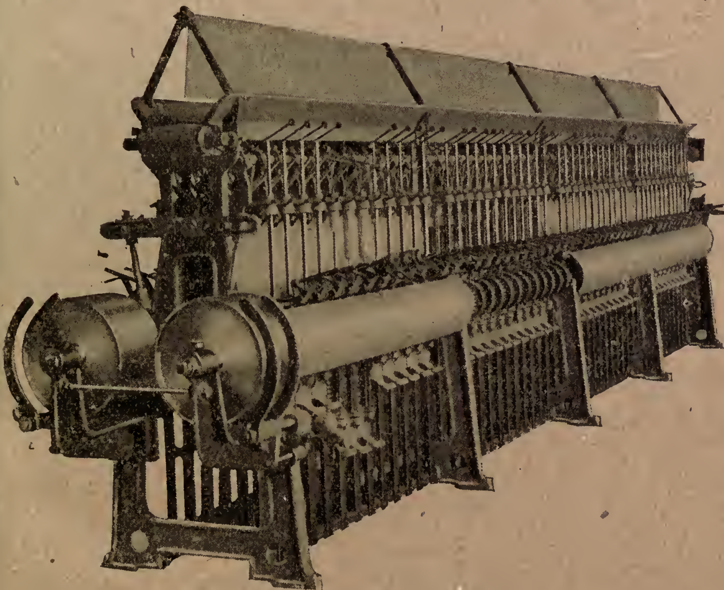


FIG. 48.—Douglas Fraser cop winder.

Stop motions are provided to stop the spindle when the cop is the required length and when the yarn breaks or runs out. The tension of the yarn is regulated by a compensating arm connected to the stop motion. The hand levers are conveniently placed to the workers' right hand and directly connected to metal clutches.

The pitch of spindles of cop machines which wind from the spinning bobbin is usually either $4\frac{1}{2}$ in. or 6 in. according to the size of bobbin to be unwound. For winding from the hank the pitch of spindles must be greater so as to allow

room for the swifts or ryces, the usual pitch of such machines being $7\frac{1}{2}$ in.

Messrs. Douglas Fraser's $4\frac{1}{2}$ in. pitch machines are built from one to five carriages long, i.e., from 24 to 120 spindles. Thus 6 in. pitch machines have the same number of carriages but from 18 to 90 spindles. The hank machines are built on similar lines but have from 16 to 80 spindles. The machines are usually double-sided with a separate belt drive to each side of the machine.

A $4\frac{1}{2}$ in. frame of 120 spindles occupies floor space 26 ft. 9 in. × 3 ft., requires $7\frac{1}{2}$ h.p. when running at 436 r.p.m., and weighs approx. 95 cwt. net.

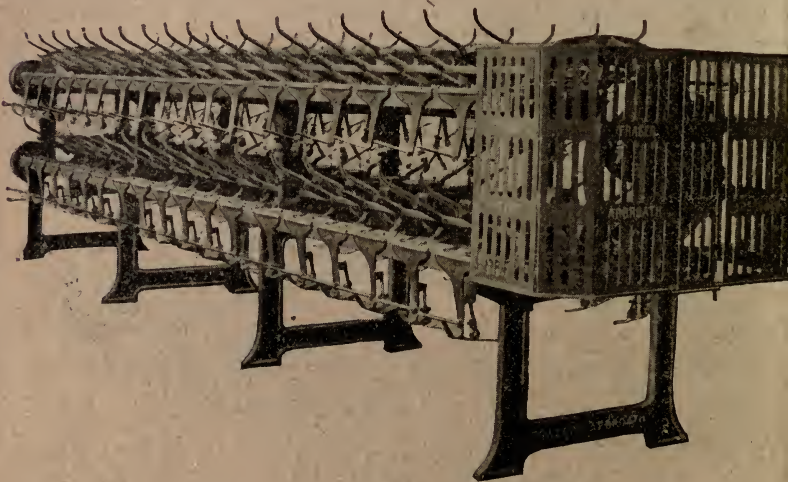


FIG. 49.—Douglas Fraser spooler or roll winder.

A 6 in. frame of 90 spindles occupies exactly the same floor space and requires $5\frac{3}{4}$ h.p. when run at 400 r.p.m. It weighs approximately 82 cwt.

A $7\frac{1}{2}$ in. frame of 80 spindles occupies floor space 29 ft. 3 in. × 5 ft. 7 in., requires 5 h.p. when run at 320 r.p.m., and weighs approximately 72 cwt. net.

Practically all warp yarn is now roll wound or spooled, as it is still misleadingly called in Dundee. Among the best machines for carrying out this operation are those made by Messrs. Douglas Fraser and by Messrs. Combe, Barbour. These machines are usually double-sided and doubled banked or decked when intended to wind from the spinning bobbin. When made to wind from hanks they are single banked or

decked owing to the wide pitch required by the swifts or ryces. The size of rolls made are from 8 to 10 in. long by 6 to 9 in. diameter.

Adjustable automatic stop motions are provided to stop the roll when it has acquired the desired diameter. About 1 h.p. for every 20 spindles is required to drive these machines.

One of the main features of the Douglas Fraser machine is the adjustable cam for traversing the yarn. It is made of two heavy machine-cut discs bolted to a flanged boss and running on a hardened steel stud. Thus the working faces can be brought closer together to take up wear. It is important to obviate friction on the yarn and breakages, that the thread guide be reciprocated as slowly as possible, consistent with the getting of firm, well-built, square-ended rolls. The traverse rod levers may be individually adjusted, so that in a double-banked, double-sided machine four different lengths of rolls may be made simultaneously if desired.

The bobbin drag is of great importance in machines of this sort if clean, square-ended, densely-built rolls are to be produced. The following types of drags may be mentioned:—

(1) The roller type (automatic adjustment) is a patent arrangement whereby the pressure on the bobbin is relieved as its diameter decreases.

(2) Adjustable torsion spring with spring bobbin spindle.

As regards production—winding 8 lb. yarn and attending to 20 spindles, a good winder should take off between 4 and 5 spyndles per spindle per ten-hours' day and winding off 4 in. spinning bobbins on to rolls 10 in. × 9 in. Much heavier machines are used for winding jute rove and rope yarns. Such machines are single-banked and single-sided, 6 spindles per machine, 16 in. pitch, and make rolls up to 14 in. long × 15 in. diameter, winding from 10 × 5 in. bobbins dragged by weights or provided with tension rails. Such a machine will wind up to 300 lb. of yarn per hour and per spindle.

The yarn traverse upon the jute roll winder or "spooler," as it is still called in Dundee, may usually be shortened if desired until it is as short as 6 in. In this case a collar has to be fixed upon one end of the spindle carrying the wooden tube and a short tube used. Although this arrangement brings the roll to one side and has a tendency to make it slightly conical it passes muster in practice.

As upon the roll winder, the roll is driven by friction against the fluted spool drivers, against which it is pressed by means of levers and weights. The rate of winding is

8

uniform, being independent of the diameter of the roll and equal to the constant angular velocity or surface speed of the surface drum upon which the roll lies. The tension of the thread is kept fairly uniform by means of spring pressers

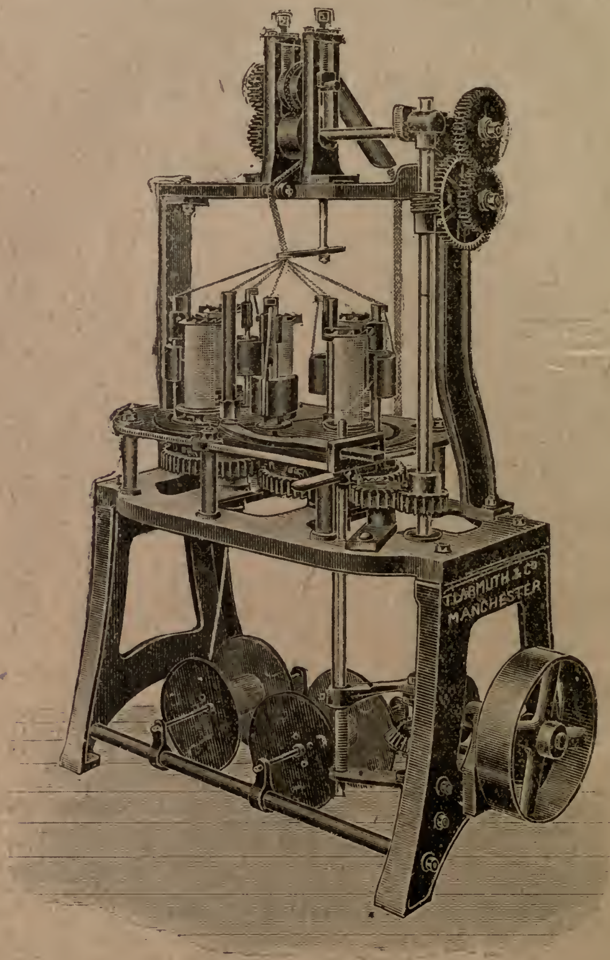


FIG. 50.—Jute plaiting machine.

which bear against the surface of the yarn upon the spinning bobbin. They press more forcibly at the right time, i.e., when the bobbin is full and when the yarn is being drawn off the circumference of a larger circle and when it consequently has a greater purchase. The same remarks apply

equally to the cop winder. Although in the roll winder some space is lost by the quick crossing of the yarn upon the cheese, yet on account of the space occupied by the flanges of the old warpers' spool, a cheese of like bulk will contain a greater length of yarn, while the cost of bobbins and breakages, cost of carriage, and trouble of getting quick return of the empty bobbins is done away with.

The spinning section of the present treatise would be incomplete without some mention of "oakum" for some classes of which jute is now largely used. Plumbers' oakum, for instance, as largely used in America, is made entirely from jute, impregnated with pine tar, and is used to caulk the joints of cast-iron pipes, soil pipes, water supply and waste-water pipes. Plumbers' spun oakum is the cheapest grade of oakum produced and is most popular in the American plumbing trade. It is made of jute, jute waste, and carded jute bagging, and contains a larger percentage of tar than any other grade of oakum. When coiled or balled this spun oakum is ready for the market. Unspun, or in its loose state, jute oakum is also used for caulking horses' hoofs.

Rope oakum is also made entirely of jute, takes the form of a rope about ½ in. diameter wound in coils of about 50 lb. each. In its untarred state it is used for caulking lead, soil, and iron pipe.

Jute waste is prepared for oakum by carding in the usual way. It is best impregnated with tar after carding, the bales being dipped into the boiling tar-pot and then allowed to drain. The tar used is the best Stockholm tar.

The spinning of oakum is best done from the sliver can upon a spinner of the Ronald type with horizontal spindles.

We have mentioned carded jute bagging. Jute bagging and hessian can be successfully shredded upon a special card clothed with saw-toothed garnett wire lapped spirally.

Analogous to oakum is carded jute carbolized and made up into neat rolls ¼ lb. upwards, with coloured paper band used by veterinary surgeons, and we believe not despised for medical treatment on the battlefield. The material is batched with carbolic acid emulsion prior to carding. The rolls we have mentioned are made from the sliver can, the material being formed into a roll upon a surface drum.

Fig. 50 shows the type of plaiting machine suitable for braiding jute yarns for the manufacture of alpargata, the soles of shoes as largely worn in South America, &c. These machines carry the bobbins of yarn on the vertical spindles

shown, which are caused to move round in a zig-zag path so that the yarns cross and recross each other. Plaiting machines for this purpose may have four heads, each head containing five spindles for 0·844 in. bobbins. The machines are power driven, and as the braid is made it is wound upon large bobbins.

The best high-speed machines are entirely self-contained and are of the slide plate type. They are formed with two circular racks, one of which is stationary, while the other revolves at a high speed. The plaiting of the threads is effected by pinions which gear into the racks and alternately carry the threads over and under each other as the braid is

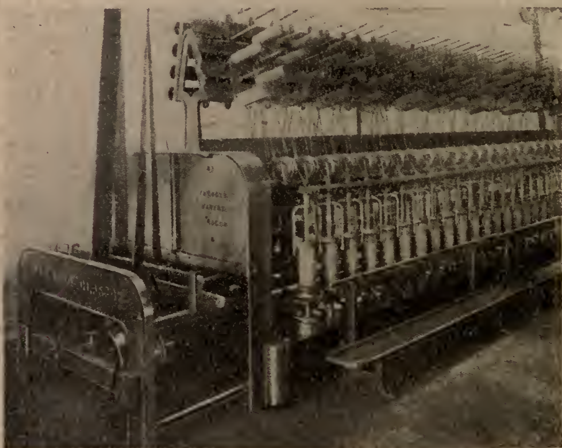


FIG. 51.

formed. Stop motions are provided to arrest any head of the machine when a thread breaks. The production in yards per head per hour is 100 approximately. A 12-head machine should be sufficient for a production of 50 dozen pairs of soles per day out of plait weighing 7 lb. per 100 yards.

Fig. 51 shows a flyer twister which is very suitable to make the three-ply 8 lb. twist which is a current article in the Dundee jute trade. The frame is fitted with patent flexible doubling spindles which may be run at a comparatively high speed as they have not to be stopped by hand as in a spinning frame, but are brought to rest when the stop motion is brought into action. This stop motion is constructed in

such a way that when an end breaks or runs out, the delivery of yarn and the revolution of the spindle stop simultaneously. The former is accomplished by raising the upper delivery roller out of contact with the lower roller which drives it, and the latter by raising the tension roller which keeps the spindle band tight. A good stop motion applied to the twisting frame is of the greatest possible value in producing good work. It should act instantaneously, leaving a perfectly twisted thread between the feed roller and spindle, and the broken end ready to be pieced in the single behind the delivery roller. A neat piecing in the single strand and the proper amount of twist, where a piecing is made, are ensured, while bunch knots, singles, doubles, and waste are avoided. No time is lost in stooping down, stopping spindles, seeking the end upon the bobbin and bringing it through the delivery rollers. Each bobbin may be doffed when filled, thereby saving the necessity of stopping the frame for doffing. The turns per inch twist required by the usual plies of jute yarn are on the basis of three turns per inch for three-ply 8 lb., while to-day's charges for twisting are—48 lb. and heavier, two-ply, £4 per ton; ditto, three-ply, £3 10s. per ton; ditto, four-ply and up, £2 10s. The putting of this into 14 to 28 lb. balls is usually charged at 32s. 6d. per ton. Tubing the same costs 27s. 6d. per ton.

Jute twines for sewing coal-bags, &c., are practically always tarred either in hanks, warps or hanks linked together in chain form. In the tarring machine the chain or warp first passes over a hook or wooden spool, which guides it into the tar tank under the immersion rollers. Before leaving the tank it passes through a squeezing slot to the drawing and squeezing rollers. Lever pressure gets rid of most of the surplus tar as the yarn passes through the slot, the tar running back into the tank. The average speed of the twine through the machine is about 75 ft. per minute. Stockholm tar should be used, while the tank should either be steam jacketed or fitted with a steam coil.

Jute twines are made upon similar but heavier machines to that used for producing three-fold jute twist. Up to six and more ply of 10 to 20 lb. yarn may be used to obtain the desired size and strength. A great deal of American commercial twine is made of jute. Its grist or weight is based upon what is termed a "spinal," which is 43,200 ft., and the yarns are made in pounds, which are merely a division of the spinal. These pounds run from 10 to 150. As an

example, four-ply jute wrapping twine is made from 20-lb. yarn. Therefore we divide the spinal, 43,200 ft., by 20, which gives 21,000 ft. The average allowance for twist is 5 per cent., which amounts to 108 ft., and this is deducted from the 2,160 ft., leaving 2,052. In making a four-ply twine, we divide the 2,052 by 4, which gives us 513 ft., and this is the approximate yardage of four-ply jute wrapping twine.

In making polished twines, a deduction of 10 per cent. instead of 5 should be made, as polishing adds to the weight of the twine. 20-lb. yarn is used for Nos. 1 and 2 jute wrapping twine. Nos. 1 and 2 tube rope is made from 50-lb. yarn; wallpaper twines from 40-lb. yarn.

No.	4½	coarse	twines	measure	300	ft. to the lb.
,,	5	,,	,,	,,	250	,, ,,
,,	6	,,	,,	,,	200	,, ,,
,,	7	,,	,,	,,	160	,, ,,
,,	8	,,	,,	,,	110	,, ,,
,,	9	,,	,,	,,	85	,, ,,

In twisting frames in which a delivery roller is used, the twist is changed by increasing or diminishing the speed of that roller and consequently augmenting or decreasing the delivery. The speed of the spindles remaining constant, the degree of twist is inversely proportionate to the rate of delivery. The principle is exactly the same as in the spinning frame. The roller is sometimes made to turn in the reverse direction to what it would be for spinning, and the yarns from the spinning bobbins or cheeses in the creel guided under and round the bottom delivery roller and through the hip of the top pressing roller, then back round a guide and over the top of the delivery roller (on which it lies in a groove), through the thread-plate eye, to the twisting action of the flyer or spindle.

Jute twines are seldom or never cabled, but jute cordage frequently is in order to get increased strength and wearing properties. Heavy twines and small cordage is frequently made upon single or double horizontal stranders, with, say, 10 × 8 or 12 × 10 in. take-up bobbins. Such machines make very good 601 twine out of 6-ply, 48 lb yarn. These machines, as well as rope machines of similar type, have no delivery rollers, the yarn being drawn from the creel and into the machine by means of haul pulleys in the flyer head, the twist being changed by means of the twist pulley, which drives the twist tube, and through it affects the speed of the haul pulleys.

To make rope, the uptake bobbins from the twisters, stranders or formers just described may be put in the layer or rope-closing machine, and turned upon their axis in such a direction that the twist is kept in the strand or even hardened, while the strands are twisted together in the opposite direction into a rope, which is either wound upon a large bobbin or coiled direct from the machine, as in fig. 52. We may here say that

FIG. 52.—Rope-making machine.

in twisting yarns into twines or strands, the twist is put in in the opposite direction to that in which it was when the yarn was spun, and similarly in cabling, laying or closing, the direction of the twist is again reversed, becoming again similar to the spinning twist as regards direction.

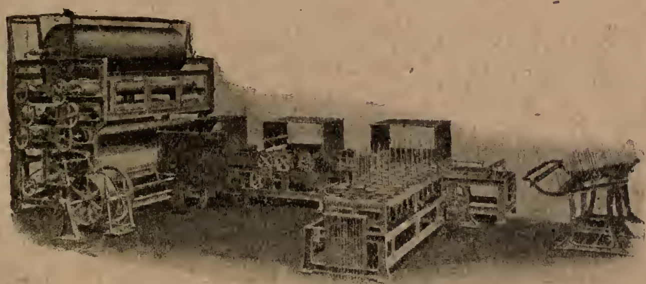


FIG. 53.—Twine polisher.

Twine Polishing.—After the twine has been twisted it is generally sized and polished upon a machine, as illustrated in fig. 53. This is done by winding it from bobbin to bobbin through one or more starch troughs and then between squeezing rollers, which remove the superfluous starch, over circular brushes and heated cylinders, and into contact with rapidly revolving polishing rollers.

The following recipe has been found a good one for polishing jute cordage:—

Starch, 8 parts; glucose, 3½ parts; water, 60 parts. Place the starch in a large tub and add cold water gradually. Next add the glucose, stir it, and boil for twenty minutes. Then make up: Borax, 1½ parts; talc, 2 parts; lithophone, 3 parts; gelatine, 3; and water, 50 parts. Heat the mixture to dissolve the borax and gelatine. Then combine the two mixtures well, stirring the while, and boil the whole for twenty minutes. Use when cold. Add salicylic acid, 1 per cent., if it is to be kept. Lithophone is a mixture of sulphate of zinc and barium sulphate.

Balling Twines.—Twines are usually wound into balls weighing from 4 oz. to 84 lb. In balling machines the twine is wound upon a slowly revolving spindle or "peg" by a quick running flyer, the desired form being given to the ball by the variable inclination given to this peg to the axis of the laying on flyer. For fine twines and small balls the machine may have two or more balling pegs and flyers. For large balls the machine has usually only one. The machine may be either hand or power driven.

(For further information on rope and twine making, see our book, "Rope and Twine Making," 6s. 6d. post free.)

CHAPTER XI.

WARP PREPARING.

The first operation in jute weaving is the preparation of the warp for the loom. If the factory is in connection with a spinning mill, the warp may be prepared direct from the spinning bobbin in the same way as a chain or warp is prepared for sale to the twine or rope maker for finishing in the walk, viz., by means of a warping mill such as is shown in the figure. The yarn may also, of course, be bought from the spinner in the form of rolls or cheeses wound by him from the spinning bobbin upon the roll-winder or spooler as it is called in Dundee and previously described. These cheeses contain, of course, a much greater length of yarn than do the spinning bobbin, and consequently run out much less frequently and give less trouble in consequence.

In connection with the warping mill shown, as the bank or bobbin cree carries a maximum number of spools, the ends of warp required must be divided into a convenient number of "bouts." Thus to form a chain or warp upon the mill, having in all, say, 476 ends as required by an 11 porter, 40 in. hessian—seven bouts of 60 spools and one bout of 56 spools may be run upon the mill. The circumference of the mill may be from 10 to 13 yards, and it may have from 24 to 30 spokes and rails. Its height is usually from 6 ft. to 7 ft. 6 in., giving a working space of about 1 ft. less.

The warper first fills the creel with spools, and then drawing the ends from each in regular order she draws them through the eyes of the "hake" or guide reeds which are fitted in the hake box. There are two guide reeds in the box, alternate threads passing through each and both being movable vertically, the yarn may be divided equally when it is desired to form the lease.

The mill is turned in either direction by a hand wheel or a similar belt-driven arrangement, a band passing round the periphery of the mill at the bottom. The hake box is raised and lowered as the mill is turned in one direction or the other

by means of a worm upon the central axis of the mill driving a worm pinion upon a horizontal overhead shaft, carrying a sprocket wheel upon the extremity over the hake box. A chain attached to the hake box passes over this wheel, and in

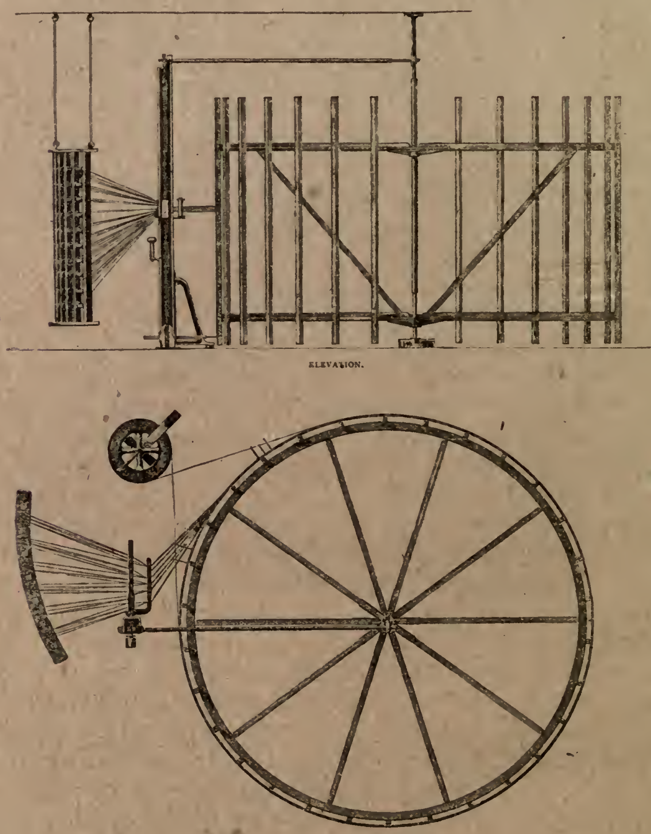


FIG. 54.—Warping mill.

this way the hake is raised and lowered so that the yarn may be wrapped around the mill in spirals.

In an older form of mill the hake box is suspended by a cord fixed at one end and passing round four pulleys to the axis of the mill, around which it is lapped. The travel of the box is consequently only one-fourth that of the length of cord wound

upon the central axis. The diameter of this latter is about 2 in., so that the pitch of the spiral lap is $\frac{2 \times 22}{4 \times 7} = 1\frac{1}{2}$ in.

Suppose that a chain or warp 650 yards in length has to be ruled or marked for 5 cuts upon a 13-yard mill—then $\frac{650}{13} = 50$ rounds of the mill will be required. A half bout is equal in length to the circumference of the mill multiplied by the number of spirals from top to bottom of the mill and a full bout is double that and produced by an up and down movement of the hake box.

The warper begins with the hake box at the top of its course. He knots the ends together which he has drawn through the guide reeds, divides the yarn equally by means of the hake and passes the yarn thus divided over the first and second of the three forks. Again dividing the yarn by means of the hake, he passes the yarn over the third fork, thus forming the "thread by thread" or drawers' lease. He then proceeds to make the 50 turns of the mill required to warp the 650 yards which it is desired to produce, taking great care that no ends break or spools run out while so occupied. When the required number of turns of the mill have been given, the lower forks, also seen in the plan, are inserted and the warper proceeds to form or pick the "pin" or beamers' lease. This he does by counting off the threads in the guide reed, or dividing the total number of threads in the bout into a convenient number of parts, which he passes alternately over and under the first and second of the lower forks and repeating the operation while turning the mill back in the opposite direction. When the upper forks are reached the drawer's lease is formed as before and then again once more before running down for the third half-bout. At the same time the hake is "tempered" or lowered about $\frac{1}{2}$ in. so that the spirals of yarn may not be built one on top of the other, this is usually done by letting out one tooth of a ratchet wheel provided for the purpose. The process is repeated in the case in question until seven bouts are complete, when four ends are broken down from one edge of the hake and an eighth bout put on, thus forming a chain of 476 ends. While the last bout is being put on the warper should mark or reel the yarn at the proper points for cutting when woven, by counting off the proper number of rounds,

in this case ten for five cuts. When finished the yarn is cut and the ends tied round the first fork as at the beginning. In order that both the drawers' and the beamers' lease may be preserved, bands are passed between the threads at the forks and firmly tied. Then the warper lifts the yarn off the first fork and proceeds to draw it away, linking it into a chain while so doing. If he knots the ends hanging from the hake, divides the yarn and forms a drawers' lease round the top forks, he may start a second chain while linking up the first.

If a very large number of ends are required in the chain, the mill may become overloaded before a sufficient number of bouts have been warped. In that case it is better to form two or more chains, which may be afterwards run together in the beaming process.

An ingenious linking machine has been devised to link up the chain mechanically, revolving and intersecting hooked arms doing the work usually done by hand.

To find the number of rounds of the warping mill and the number of extra spokes required to make any given length of warp, divide the given length by the circumference of the mill and the result in the number of rounds. Then multiply any remainder there is by the number of spokes in the mill and the quotient is the number of extra spokes required.

Example.—How many rounds and spokes will be required to give 105 yards of warp or chain on a mill, 6 yard mill containing 16 spokes?

Answer:—

$$
\begin{array}{r l}
6)105(& 17 \text{ rounds} \\
102 & \\
\hline
3 & \\
16 & \text{spokes} \\
\hline
6)48 & \\
\hline
8 & \text{spokes.}
\end{array}
$$

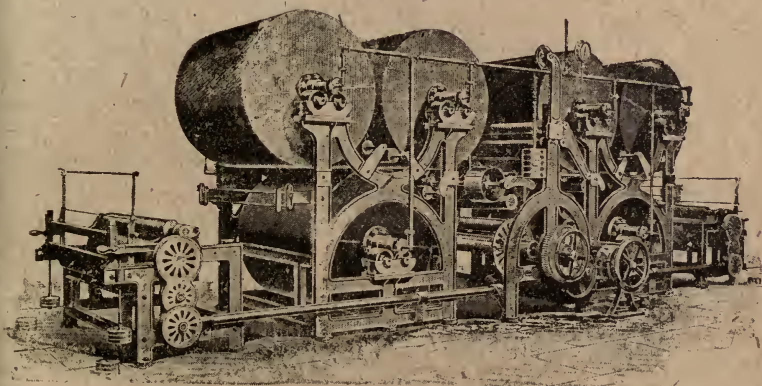
Answer: 17 rounds and 8 spokes.

If any allowance is to be made for the "thrum," one or two spokes must be added to this result.

If we have a chain or warp of which we know the grist or size of the yarn in pounds per spangle, also the length and weight of the chain, the number of single ends or runners it contains may be found as follows: First divide the weight

of the chain by the grist of the yarn, this gives the number of spangles contained in the chain. Then divide 14,400 (the yards per spangle) by the product of the length of the chain in yards and the number of spangles of yarn in the chain.

In the factory, chain beaming follows chain warping. The end of the chain containing the beamers' or chain lease is passed round a set of three tension bars set about 16 ft. behind the beaming machine. By means of the "pin lease" the beamer spreads the warp over the swinging and fixed "raddles" to the width of the beam, which is a few inches more than the width of the warp is to occupy in the reed of the loom. After passing through the fixed raddle, or evener, the ends are attached to the loom beam, upon which they are wound at a suitable speed, being firmly and solidly built by means of a pressing roller. Two speeds are given to the



Yarn Dressing Machine.
Garn-Schlicht-Maschine.
Шлихтовалная Машина.

FIG. 55.

beaming machine by means of an arrangement consisting of two fast and one loose pulley, combined with gearing. However, it is now more usual to warp or beam the yarn from spools, rolls or cheeses upon the yarn sizing, starching, or dressing machine. Such a machine is usually made double and may have as many as three copper drying cylinders on each side, each, say, 48 in. in diameter, also sow, size or starch box and squeezing rollers and a V bank to carry up to 300 spools. If there are less than two drying cylinders a

side, a fan is also usually provided to help to dry the yarn. The ends or runners of warp from each creel or band are combined upon the loom beam in the centre. The large drying cylinders are steam heated, the warp being dried as it passes round them. Occasionally the yarn is merely damped and then dried, with the object of smoothing it or laying the hairs or outstanding fibre. The ends, as drawn from the creels at either side of the machine, pass through a coarse reed, then through a size box and around the drying cylinders. They are then wound up evenly, together with a similar set of ends from the other side, on a weaver's beam placed in the centre. The weight added to the warp by sizing varies from 5 to 25 per cent. The usual dressing consists of 90 per cent. of farina or wheaten flour, 8 per cent. of tallow or lard oil, and 2 per cent. of zinc chloride. When farina alone is used the mixture should not be boiled but simply raised to boiling point. A very good dressing for jute warps may be made as follows:—Steep together for three days American flour and water in the proportion of 2 lb. of flour to 1 gallon of water. Add 1 lb. of alum and 2 lb. of lard oil for every 20 gallons in steep and boil the whole together for one hour keeping the mixture in motion while boiling.

The speed of the yarn through the dressing machine depends upon the surface speed of the squeezing rollers, the drag of the uptake being regulated as the beam fills by a friction plate and bowl drive.

In order that the threads which are to form the warp of the cloth may be placed in such a manner that they can easily and without mistake be placed in convenient order in the loom, they should pass alternately over and under the lease rods of the dressing machine, so that the first and all the odd numbered threads pass over the first lease rod and under the second, while the second thread and all the threads of even number pass on the contrary under the first and over the second lease rod. This part of the warp, which is so arranged, is called the lease and serves the purpose of enabling the drawer-in to find each thread in the order in which he required it to pass through the heddle eyes and through the reed of the loom.

Warping and dressing requires great attention. The dresser should not only watch that no threads are missing, but also that the lease is well made and also that the threads are kept at an equal tension.

WARPING TABLES.

Table for Plain.

	8	9	10	11	12	13	14	15	16
Sett of Cloth in Porters.	8	9	10	11	12	13	14	15	16
Width of Cloth in inches	Ends or runners on loom beam for single warp.								
18	168	186	204	228	246	270	288	320	330
19	176	196	216	240	260	284	304	336	348
20	184	206	228	252	274	298	320	348	366
21	192	216	240	264	288	312	336	360	384
22	202	226	252	276	302	326	352	378	402
23	210	236	262	288	316	342	368	394	420
24	220	246	274	302	330	356	384	412	438
25	228	256	286	314	342	372	400	428	458
26	238	268	298	326	356	386	416	446	476
27	248	278	308	338	370	402	432	462	494
28	256	288	320	352	384	416	448	480	512
29	266	298	332	364	398	430	464	498	530
30	274	308	342	376	412	446	480	514	548
31	284	318	354	388	428	460	496	532	566
32	293	330	366	402	438	476	512	548	586
33	302	340	378	414	452	490	528	566	604
34	312	350	388	426	466	506	544	582	622
35	320	360	400	440	480	520	560	600	640
36	330	370	412	452	494	534	576	618	658
37	338	380	422	464	508	548	592	634	676
38	348	390	434	476	522	564	608	652	694
39	356	402	446	488	534	578	624	664	714
40	368	412	458	502	548	594	640	686	732

Reeds and Fineness of Cloth.—The "porter" system of ndicating reeds is that usually used in the jute trade. This ystem shows the number of porters of 20 dents each which here are in 37 in. Thus an 11 porter 40 in. hessian will ave $\frac{11 \times 40 \times 40}{37} = 476$ warp ends.

For double warp the number of ends required is, of course, louble the above. For plain cloth single warp, two warp hreads are drawn through each split of the reed, and for willed cloth two runners through one split and one through he next to make the twill show, hence the splits of reed re one-half the number of runners given in the case of plain loth, and two-thirds in the case of twill. Plain cloth "sinks"

TABLE FOR TWILL.

Sett of Cloth in Porters.	8	9	10	11	12	13	14	15	16
Width of Cloth in inches	Runners on loom beam for single warp.								
18	182	206	228	250	274	296	320	342	364
19	194	218	240	266	290	312	336	362	374
20	204	230	252	279	304	330	354	380	404
21	212	240	266	292	318	346	372	398	426
22	224	252	280	307	334	362	390	418	444
23	234	262	290	320	348	380	408	438	466
24	244	272	306	334	364	396	426	456	486
25	254	284	318	350	380	412	444	474	506
26	264	296	330	362	396	432	462	494	526
27	272	306	342	376	410	446	478	512	548
28	284	320	354	390	426	462	496	532	568
29	294	330	368	404	440	478	514	552	588
30	302	342	380	418	456	496	532	570	608
31	314	354	392	532	470	512	550	588	628
32	324	366	406	446	486	528	568	608	648
33	332	376	418	460	502	544	584	626	668
34	342	388	432	474	516	560	602	646	688
35	354	400	444	490	532	578	620	666	710
36	362	410	456	502	548	594	638	684	730
37	372	420	470	516	562	610	656	702	750
38	384	432	480	530	578	628	674	722	770
39	394	442	492	544	594	644	692	740	790
40	404	452	504	558	610	660	710	760	810

or contracts more in width during weaving than does twilled cloth. In the above tables an allowance of $1\frac{1}{2}$ in. on 37 in. in the reed has been made for twilled cloth and 2 in. for plain. The contraction in length during weaving may be taken at 10 to 12 per cent.

When the warp has been dressed or beamed, the beam is put into a drawing-in frame and a set of rods put through the threads where the lease cords are. Then a set of heddles or healds are hung down from the beam and the ends drawn through the heddle eyes as required by the sort of fabric to be woven, as will be explained later on. This drawing in is done by hand or by a newly-invented machine. The yarn is drawn through the splits of the reed in much the same way by means of a reed hook, one, two or more ends passing through each dent. The warp is then ready for the loom.

CHAPTER XII.

WEAVING.

The cone overpick loom, as shown in fig. 56, is almost universal in the jute trade. In this loom, the picking arms proper are wholly above the shuttle boxes. The picking mechanism (fig. 57) consists of a picking wyper or tappet keyed to the bottom of the wyper shaft; also of a stud which carries a conical anti-friction roller and which is bolted in a tapered hole in a vertical shaft, to the top end of which the

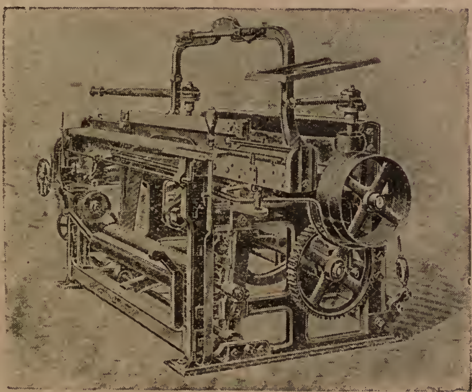


Fig. 56.

wooden picking arm is clamped. The top of the vertical shaft is made in two parts, an upper and a lower, the faces of which come together and are saw-toothed to ensure a rigid grip, while permitting any necessary adjustment in the position of the arm. As the bottom shaft revolves, the wyper drives the cone stud through a certain angle, causing the vertical shaft to make a partial revolution and the picking arm to do likewise. A leather strap or picking band is connected to the extremity of the picking arm and to the buffalo hide picker on the picking spindle and thus gives motion to the shuttle. The usual speed of hessian looms is about 125 picks per minute.

A jute sacking loom, 33 in. R.S. (reed space) fitted with plain and three-leaf twilling motions weighs nearly 1 ton.

Brake Let-off. A very good arrangement of brake let-off for the yarn beam consists of W.I. bands lined with leather, which are attached at one end to fixed hooks and at the other end by a chain and an adjustable screw to the short arm of a lever, the long arm of which may be depressed by the weaver when she desires to slacken the friction in order to turn the beam back or forward by means of a hand wheel, side shaft, bevel pinion and wheel.

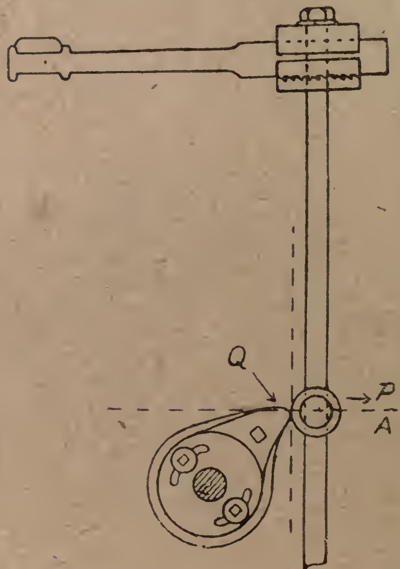


FIG. 57.

The speed of the loom varies from 160 picks per minute for a 32-in. R.S. loom to 80 picks per minute for a 160-in. R.S. loom, weaving floorcloth hessians.

The weavers usually mind two looms apiece and occasionally three narrow looms or one wide loom. Temples are unnecessary and seldom used in jute weaving, as are also shuttle guards. Cloth for padding, bags, &c., for cutting up are made in narrow widths in a wide loom with centre selvedge attachment. The standard loom for weaving 40-in. hessians is a $46\frac{1}{2}$-in. R.S. loom.

The shuttle is an indispensable organ of the loom. It

carries the weft yarn across the loom and through the warp threads. Shuttles are made of various sorts of wood, and at various prices. Cheap shuttles are often dear at any price. Many weavers prefer boxwood shuttles, but cornel or persimmon wood is also much used and is not so heavy. When shuttles arrive at the mill they should be steeped in oil for a few weeks and then thoroughly dried. Before being put into the loom the shuttle should be thoroughly examined to make sure that it is of exactly the same length, breadth, height and weight as the other shuttle with which it is to run, this being a most important point if the loom is to run properly.

Some important details connected with the shedding motion of the loom are: (1) The movement of the heddle leaves should be eccentric, so as to minimize the strain and breakages of the warp threads. (2) The heddles must be in continuous contact with the wypers throughout the whole revolution. (3) The shed must be full open when the shot is being beaten up. (4) To produce well-covered cloth the line of the warp requires to be depressed from the horizontal when the shed is closed.

The *let-off motion* of the loom determines the rate at which the yarn is drawn from or given off by the yarn beam. It works in conjunction with the take-up motion to regulate the "pace" of the yarn. Hence both are sometimes called "pacing motions." Let-off motions may be divided into two classes, i.e., negative and positive. The former simply puts a brake on the yarn beam, which is pulled round by the up-take and shedding motions. Most linen looms have negative let-off motions. When a positive let-off motion is applied the yarn is usually drawn from the beam by a pair of rollers, the surface speed of which must be slightly greater than that of the "sand beam," or feed roller, which draws the cloth forward at a speed corresponding with the number of shots of weft required per inch. This difference in the surface speed of back and front rollers is necessary on account of the contraction of the warp threads due to the insertion of the weft in each shed. The motion of the feed roller, or sand beam, is a positive one produced by gearing. The rule to find the number of teeth required in the change pinion to produce a given number of shots per inch of cloth is as follows:—

Rule.—Multiply the number of shots on 1 in. by the circumference of the feed roller in inches. Divide the product thus obtained by the number of teeth in the ratchet wheel,

and use the quotient as a divisor in dividing the number of teeth in the feed roller.

The Stop Rod or Shuttle Protector is provided to protect the warp from injury in the event of the shuttle, from any cause, failing to reach its shuttle box and leave the shed before the reed beats up the weft. There is a "frog" or stop attached to the front of the framing of the loom. A lever comes in contact with this stop if the shuttle is not in the box at the proper time, but if the shuttle reaches the box in time it presses back a spring or lever, which acts upon the first-mentioned lever and raises its point, so that it clears the top of the frog as the lay makes its forward

Jute loom pickers.

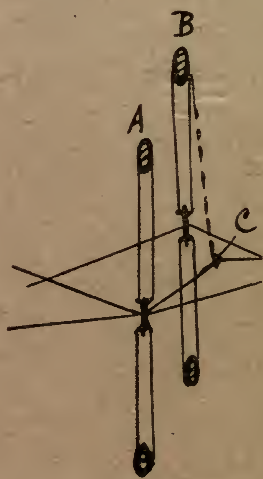


FIG. 58.

stroke; but if the shuttle does not enter its box the point of the lever remains down and strikes the shoulder of the frog, the force of the concussion knocking off the loom by throwing the belt on to the loose pulley.

Splits.—By the use of a centre selvedge motion, two or three breadths of narrow cloth can be woven in a broad loom, thus reducing the cost of production. The selvedges are not quite so firm as outside selvedges, and to separate the pieces the weft threads uniting them must be cut through. The selvedge produced may be either single or double, the selvedge being formed by bringing the binding thread alternately to either side of two or four warp threads, passing underneath them and by holding it up as the shed is formed so that the

weft thread passes always underneath it after passing over the adjacent warp thread. Whatever the weave of the cloth may be the structure of the selvedge is always plain cloth. In jute weaving the method employed is usually to attach a flying heddle to the front leaf of heddles, through which flying heddle the binding thread passes as well as being drawn through an eye on the back leaf. One selvedge thread is drawn on the back leaf and another on the front leaf. The looping thread does not pass over the lease rods, but comes direct to the heddles from the bobbin on which it is wound, and which is paced by weights to keep the thread at the required tension. The tighter the thread the stronger the selvedge. The looping thread just rises to about the middle of the shed. It is always above the weft thread and under the two selvedge threads. The length of the flying heddle must be adjusted to make the most of both sheds. When this heddle is not the proper length, an unequal tension is thrown on the thread and the selvedge is spoiled.

The Double Cloth Principle may be used in the weaving of jute sacks and bags, which may be made tubular and then cut into lengths and sewn, or else joined together at one side of the loom, forming the bottom, with both selvedges at the other side forming the lip, and woven together for, say, 1 in. at each side, completing the bags, which are cut apart when the web is taken out of the loom.

Jute Cloths.—Hessian is a coarse, plain, jute cloth, principally used for baling purposes. A standard make is 40 in. wide, 11 porter, and weighs 10½ oz. per sq. yard. Average value, over 2d. per yard. Warp and weft are always single. As shown in the following table, the usual width is 40 in., and the usual extremes in weight 6 oz. to 14 oz. per yard. To increase the weight above 10½ oz. the weft only is usually changed. Below 10½ oz. it is usual to alter both sett and yarn counts. Sacking is either plain or twilled, double warp and weft being frequently used.

Plain jute cloths contract about 2 in. on 37 in. while being woven in the loom; twilled cloths only about 1½ in.

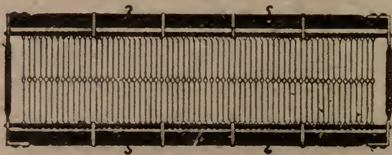
The number of splits required for any given breadth of twilled cloth may be found by dividing the product of the porters, the inches and 30 by 35½. For instance, in 8 porter 27 in. twilled sacking there are $\dfrac{8 \times 27 \times 30}{35\frac{1}{2}} = 182$ splits.

The number of splits required for any given width of plain

cloth may be found by dividing the product of the porters, the inches and 20 by 35. For instance, in 10 porter 40-in. hessian there are $\frac{10 \times 40 \times 20}{35} = 229$ nearly.

To ascertain the number of spangles of wefts in any given piece of cloth, divide the product of the inches in the reed, the shots per inch and the length of the piece in yards by 14,400.

Woven jute fabrics are built up of two sets of threads, called warp and weft threads. The warp, as already ex-



Wire healds.

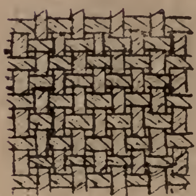


Fig. 59.

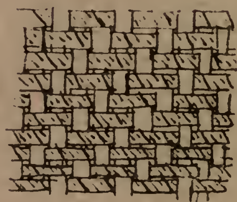


Fig. 60.

plained, is arranged longitudinally, while the weft crosses it at right-angles and passes over and under certain warp threads. The appearance and texture of the cloth almost entirely depends upon the manner in which these interlacings take place. Plain cloth, such as hessians, is produced when the warp and weft threads pass over and under each other alternately. Plain cloth is, for strength and quality of material that may be put in it, the firmest, strongest, and best weaving of weaves on makes of cloth. Fig. 59 shows the interlacings of the warp and weft threads. A twill is the simplest form of a pattern and is but a slight modification of the common plain weave. Jute sacking is usually woven on the 3-leaf

regular twill principle, sometimes with double warp. Fig. 60 shows the interlacings of warp and weft in a 3-leaf twill.

The crossing of the weft at right-angles to the warp and the interlacing of the threads is, of course, effected by propelling the shuttle carrying the cop of weft thread through a shed or division of the warp threads which are divided into two portions producing an upper and a lower line of threads. This shed must be of sufficient depth to allow the shuttle to pass freely through it. In weaving plain and twilled jute goods, this shed is produced by means of healds or heddles. In weaving simple figured goods such as some jute mattings, requiring not more than 20 leaves of heddles, the shed is also produced by heddles actuated by a dobby machine, but for more complicated patterns in jute carpetings each thread is raised and lowered independently, to form the shed, by means of a Jacquard machine. Especially with elastic warp threads, such as jute, the formation of the shed puts a considerable strain upon the tightly stretched warp threads. Consequently, in raising or depressing a thread, the motion should be slow at the commencement, gradually increasing in velocity until the centre of the traverse is reached and then gradually decrease again. Besides, the shed should remain open as long as possible during the passage of the shuttle through it. The central shedding system is that usually adopted in jute weaving. Under that system, the normal position of all the warp threads lies in a line passing over the warp rail and breast beam. To form the shed, some of the warp threads are raised and others depressed. When the pick has taken place, the two sets of threads come together again in the centre ready for the next division of the warp.

In the 3-end and 3-leaf twill (fig. 60) every third end is raised or depressed in succession, the weft passing over or under the other two. Although twilled cloth does not possess the same wearing qualities as plain cloth, it is used in sacking to give weight to the cloth, for by twilling a greater number of threads per inch both in the warp and in the weft can be put in than can possibly be put into plain cloth, the character of the working allowing the threads to lie closer together and consequently produces a stouter fabric. The larger the twill is the heavier the cloth can be made, for when the shed is open every thread of warp either above or below the thread of weft will oppose a certain resistance to the operation of weaving. Now in plain cloth, every thread is alternately interwoven and therefore opposes its proportion of

resistance, whereas in a 3-leaf twill every third thread only is intersected and, as can easily be seen, less resistance is given to get the weft in.

In a 3-leaf twill two-thirds of the warp is on one side of the cloth and two-thirds of the weft upon the other. This is accomplished by sinking two leaves of heddles and raising one every shot. The warp is drawn through the heddles as follows: One thread through the first or front leaf, one thread through the second or middle leaf, and one thread through the third or back leaf. In forming the first shed, the first and second leaves are depressed and the third is raised. For the second shed the first and third leaves are depressed, while the second is raised, while for the third shed the second and third leaves are depressed and the first raised, this cycle being repeated.

A pattern or figures are produced in jute carpetings, &c., by bringing the coloured warp and weft to the surface as desired, the figure effect on the surface of the fabric being produced by a combination of masses of weft predominating, contrasted with masses of warp predominating. The figure is produced by masses of weft floating on the surface of the cloth and stands out in contrast with the masses of warp floats in the ground as they lie at right-angles to each other. These floats or warp and weft may be produced in the form of twill by heddles, the pattern being controlled by Jacquard mechanism.

Great inventor as Jacquard undoubtedly was, he did not originate a single important feature of the Jacquard machine. His machine, in short, was simply the old draw loom made automatic. It was first introduced into England about 1818, and during the next decade came into pretty general use in the silk and linen trades for figure weaving. The modern single lift Jacquard contains most of the main features of Jacquard's original machine unchanged. Each warp thread passes through a mail centre *h* carried in a steel wire or varnished cotton cord or short harness to the bottom of which weights or lingoes are attached and hang vertically. Heald cords are attached to the upper end of the short harness and passing through holes in the comb board to keep the healds vertical converge together and are each knotted to a neck cord. The number of heald cords attached to each neck cord depends upon the number of repeats of the pattern in the width of the cloth. The neck cords are short and loop round hooks coming down from above. Thus the number

of hooks and needles required depends upon the number of repeats in the width of the cloth and on the number of warp threads in each repeat. The hooks extend up within a square frame seated on the high framing of the loom. In front of the frame and revolving on a rectangular cylinder is an endless

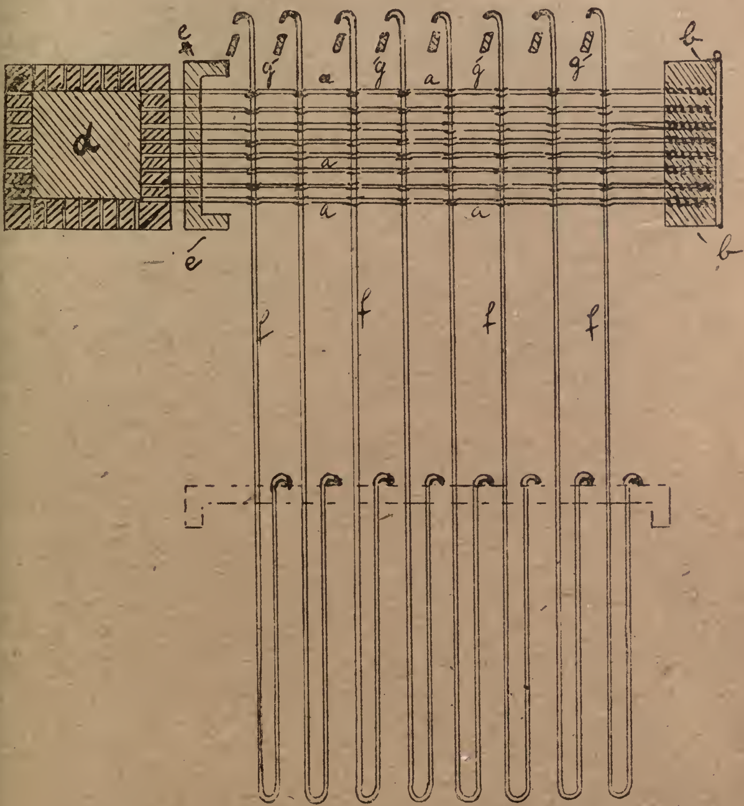


FIG. 61.

chain of perforated cards. The width and length of each card corresponds with each face of the rectangular cylinder, fig. 61. At the point where the cylinder brings the card in front of the frame is a board, *e*, pierced through by a mass of needles, *a*, lying horizontally and projecting about $\frac{1}{4}$ in., as seen in the figure, which shows what is inside the frame. At the other extremity of the projecting needles, *a*, is a box, *b*, full of springs which allow the needles to give way

to end pressure, but send them back again as soon as the pressure is removed. Between *e* and *b* the needles are linked by indentations to the vertical hooks *f*, which, as previously stated, are attached to the cords attached to the short harness healds which raise the warp threads. The vertical wires, *f*,

FIG. 62.

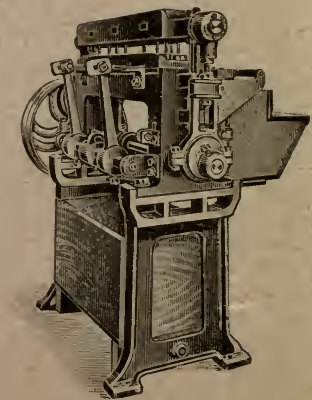


FIG. 63.—Semi-automatic peg and lace hole punching machine.

are hooked at their upper extremity, and when vertical hook on to one of a series of bars, *g*, called the grieffe. As the loom works the grieffe moves up and down. If all the hooks, *f*, are allowed to remain vertical the bars of the grieffe would lift them all and with them all the warp threads. As the cylinder, however, brings round a fresh card each time to the needle board, and as the cards press back those needles which have no perforations in the card opposite them, only some of the warp threads are raised while others remain down and a shed is formed, the formation of the shed varying with each weft thread in the repeat of the pattern warpwise. The needles, being pressed back, send the hooks to which they are linked out of the way of the rising grieffe, which in its passage upwards lifts only those hooks which the perforations in the card have allowed to remain in position. The perforations in the card, therefore, represent warp threads raised for each pick of weft. The number of rows of holes in the width of the card corresponds with the number of bars in the grieffe. If the reader remembers that the Jacquard machine is little more than an aggregation of heddles and thinks of each neck cord as a heddle cord, the seeming complexity of the contrivance will not overawe him.

The cutting of the cards is a technical operation. The designer prepares for the use of the card cutter from the design what is known as a "paint" done on "point paper," corresponding with the hooks of the Jacquard. This point paper is divided up into little squares. These squares are left white or blue or painted black or red which represents warp threads to be lifted. Perforations are cut in the cards corresponding to the coloured squares on each line. A modern piano card cutting machine can do all but read the design and cuts the perforation with an accuracy the most skilful workman could hardly hope to equal. Fig. 62 gives a general view of the machine in question. The peg and lace hole cutting machine, fig. 63, is used to cut the holes for the pegs of the cylinder, also the lace holes. When the cards are cut, they may be laced together by hand or by a Singer card lacing machine, or the tape may be sown right across the cards with a short fine stitch.

Damask.—A reverse or turn-over design is one which is turned over instead of repeating straight across. Each half is alike, but reversed. A 9-in. pattern when turned over gives an 18-in. repeat.

The Jacquard card repeating machine is an adaptation of the Jacquard principle to card punching. It can cut up to 40 cards per minute.

The repeating table is used for repeating cards from the original set, which is placed over the cylinder at the top of the machine and by pressing the treadle the punches are placed in the top plate from the punch box, according to the holes in the card requiring to be copied. The plate is then placed on the carriage of the railway press on the top of the plates containing the blank card and is then slid to the drum of the railway press, which, being turned, pierces the required holes.

When laced together the cards may be folded and set on the cylinder of the Jacquard machine when the ends are joined and the series made endless. Considerable variation occurs at this point, some sheeves of cards being arranged so that they merely fall over from one position to another, while others make a wide circle, as many as twenty cards lying in festoons supported by card wires in a cradle. These card wires are of cast steel rather longer than the width of the card, so that their ends project and rest on the sides of the cradle. They are preferably indented in positions corresponding with the three rows of lacings through which they pass, so that they cannot slip out sideways.

The double lift Jacquard machine, a general view of which is given in fig. 64, enables the loom to be run at a higher speed, for the operating parts of this Jacquard only requires to run at half the speed which those of a single-acting Jacquard will have to do. The double-acting Jacquard also produces a warp shed on the semi-open principle instead of one on the closed shed principle of the single-acting Jacquard. The great advantage of this principle is that the strain of the warp threads is reduced, the distance travelled by the warp in forming the shed being of twice the depth of the shed as in the closed shed principle. Furthermore, with the double lift machine, the cloth can be wefted closer than is possible with the single lift machine, because with the former the weft is driven into a "crossed" shed, whereas with the latter the

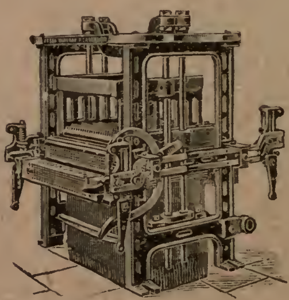


FIG. 64.

weft is driven into a closed shed. The beating up of the weft into a crossed shed produces a better covered cloth.

In this type of machine there are two sets of hooks and one set of needles, each needle being looped round and controlling two hooks. There are besides two series of grieffes which act alternately upon any hooks in their upward path.

Another modern type of Jacquard machine is the double-acting, double-cylinder machine which has two sets of needles, each passing into a separate card cylinder and set of cards. One needle of the upper set and one of the lower are attached to an adjoining pair of hooks, which are combined by two neck cords to a single harness cord. Half the cards—all the even numbers—are laced together for the top cylinder; the remainder—all the odd numbers—being laced together for the bottom cylinder.

The chief advantages of the double cylinder Jacquard is the increased time afforded for the rotation of the two card

cylinders since they are only required to strike on alternate picks. This, too, affords an opportunity of running the loom quicker without over-speeding the Jacquard. A little trouble is sometimes experienced with this machine owing to the liability of the two sets of cards to get out of their proper sequence. An automatic stop motion has been devised to overcome this defect, and immediately detect any irregularity in order of the cards.

The maximum shuttle speed in picks per minute may be attained in looms of 36 to 40 in. R.S. As the width of the loom increases the picks per minute must be reduced to give the shuttle time to cross, as it has a greater distance to travel, also a stronger pick is necessary. The gross distance travelled by the shuttle per minute is, however, greatest in looms of about 100 in. reed space.

The cone overpick depends for its energy or picking force mainly upon the speed of the bottom shaft, and owing to the reduction in speed of the wider looms insufficient picking force is developed even though the construction of the picking tappet be modified by lengthening the nose and in increasing the acceleration.

Loose reed looms are unsuitable for jute fabrics. Fast reed looms are preferable for all fabrics with heavy weft owing to greater rigidity. In a fast reed loom when the shuttle fails to reach its box the loom instantly stops by reason of the impact of a metal tongue or frog against the frog bracket which it fails to clear.

The following are some of the usual Dundee jute cloths:—

Hessian.—A plain woven cloth, single warp woven with two threads per split of the reed.

Bagging and pocketing and tarpaulin are also plain cloths, but with double warp threads, four of which pass through each split of the reed.

Three-leaf Twilled Sacking is made both with single or double warp, three or six threads respectively being passed through each split of the reed.

Four-leaf Twilled Sacking is likewise made both with single or double warp, four or eight threads respectively being passed through each split of the reed.

In weaving hessians the contraction in length through the insertion of the weft (12 shots per inch) amounts to approximately 8 per cent.

The porter system of indicating the coarseness of reed and cloth is universally employed. This system shows the number

of porters of 20 dents each which there are in 37 inches. The fineness of the cloth in porters × 20 splits or dents per porter = the splits in a reed 37 in. wide. Multiply this by the warp threads per split and we have the number of ends or runners of warp yarn in 37 inches. Divide this result by 37 and we have the threads per inch. Multiply this by the reed width and we have the total number of runners in the warp. This total multiplied by the length of warp laid gives the total yards of warp yarn required. Divided by 14,000 we have the number of spangles or spyndles required. Multiply the latter figure by the grist of the yarn in pounds per spangle, and we have the total weight of warp required. If there are to be two threads per split of the reed, the number of warp threads or runners must be even. If there are three threads per split it must be divisible by 3, and so on.

Subtract the weight of the warp from the weight of the finished cloth and we have the weight of the weft. The number of inches of weft in 1 in. of cloth is equal to the product of the shots per inch and the reed width in inches. Multiply this by 36 and we have the inches of weft in one yard of cloth. Divide the last result by 36 and we have the yards of weft per yard of cloth, which it will be seen is equal to the inches of weft per inch of cloth. Multiply by the length of the cloth and we have the yards of weft per piece. Divide by 14,000 and we have the spangles or spyndles of weft yarn required. To get at the grist of the weft required divide the total weight of weft in pounds avoir. by the number of spyndles. Three or four of the outside warp threads are usually replaced by a like number of cotton selvedge threads, as they are more elastic and less liable to breakage.

A "porter" glass has an aperture of $\frac{37}{40}$ in., 2 threads per split being understood. Consequently if 22 warp threads are seen under the glass, the cloth was woven through a 11-porter reed.

Cloth for padding, bags, &c., for cutting up are often made in narrow widths on a wide loom with central selvedge attachment. Such cloth is known as "splits." The centre selvedges are not quite so firm as outside selvedges and to separate the pieces the weft threads uniting them must be cut through. The selvedge produced may be either single or double, the selvedge being formed by bringing the binding thread alternately to either side of the two or four warp threads, passing underneath them, and by holding it up as

the shed is formed so that the warp thread passes always underneath it after passing over the adjacent warp thread. This is done as described on page 132.

Jute Cloths.—Hessian is a coarse, plain, jute cloth, principally used for baling purposes. A standard make is 40 in. wide, 11 porter, and weighs 10½ oz. per sq. yard. Average value, over 2d. per yard. Warp and weft are always single. As shown in the following table, the usual width is 40 in., and the usual extremes in weight 6 oz. to 14 oz. per yard. To increase the weight above 10½ oz. the weft only is usually changed. Below 10½ oz. it is usual to alter both sett and yarn counts. Sacking is either plain or twilled, double warp and weft being frequently used.

Gunnies are the very coarsest of jute fabrics used for baling cotton, &c. Fancy twills figure largely in Dutch mattings, carpets, squares, &c., the herring-bone twill being particularly effective.

There is also a trade in imitation Brussels, Wilton, Axminster and other kinds of carpets.

Standard Jute Cloths are 10½ oz., 40 in., 11 porter. Hessians 20 oz., 40 in., 11 porter. Tarpaulins 16 oz., 36 in., 7 porter, 9 shott. D.W. bagging 16 oz., 36 in., 7 porter, 9 shott twilled sacking.

Hessians usually fall or decline in value from 10 oz. to 6 oz. by ¾d. per ½ oz. per yard.

The following particulars of some of the ordinary makes of hessians, finishing 40 in. wide, are given by the late Wm. Legatt, of Dundee: 8 porter, 6 oz. per yard, 9½ shotts per inch, 380 ends of warp, 108 yards laid, 106 yards of cloth from loom, 107 yards finished, 7 lb. warp, 6½ lb. weft; 11 porter, 14 oz. per yard, 13 shotts per inch, 516 ends of warp, 108 yards laid, 99 yards of cloth from loom, 104 yards finished, 8 lb. warp, 14½ lb. weft.

The shotts of weft per inch shown are the shotts in the finished cloth. Owing to the stretch in finishing, the actual shotts per inch put in by the loom are rather more. As a rule it is better to make cloth from 12 oz. to 16 oz., 40 in., with 9 lb. warp, as it fills up better in the finishing and weaves better.

Tarpaulin is a plain D.W. or double-warp fabric, standard width, 45 in. Prices based on 45 in., 10 porter, 20 oz., with 12½ shotts per inch finished. Length laid, 108 yards to finish 103 yards. Warp, 8½ lb. dry or 9 lb. dressed. Weft, 14 lb.

D.W. bagging is also a double-warp plain fabric of coarse

set and heavy weft. Standard width, 44 in. A common make is 7 porter, 44 in. 24 oz., with 9 shotts per inch finished, or 38 lb. undressed weft and 8½ lb. warp. Laid length 188 yards to finish 102 yards, reed width 46½ in. to finish 44 in.

Jute bagging for cotton bales is usually 32 oz. per yard, 44 in. wide. Each bale of cotton requires 6½ yards of bagging, or for an average American crop 100 million yards.

Twilled sacking is a double-warp fabric woven with the regular three-leaf twill, two up and one down, and having three double or six single threads of warp per split of the reed. Prices are usually based on 27 in., 8 porter, 16 oz.

Wrapper canvas is from 32 to 72 in. wide and from 6 to 20 porter, 16 porter being a popular article.

CHAPTER XIII.

CLOTH FINISHING.

FIG. 65 shows the cropping machine through which the woven cloth is run after it leaves the loom and in which spiral blades or revolving cutters, working against "ledger plates," shear off any knots and loose ends from the surface

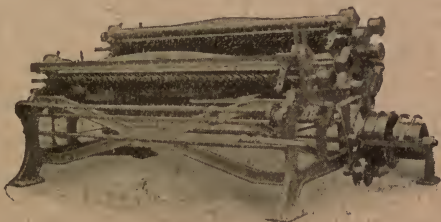
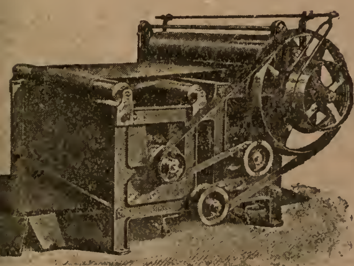


FIG. 65.

of the cloth. The old cropping machine had but two blades or spirals. A modern machine has three or more, so that both sides of the cloth may be cropped by one run through the machine. The cloth is then cleaned by rotary brushes and "plaited down." Fig. 66 shows the damping machine



Cloth Damping Machine.
Tuch-Einspreng-Maschine.
Сукно увлажняющая Машина.

FIG. 66.

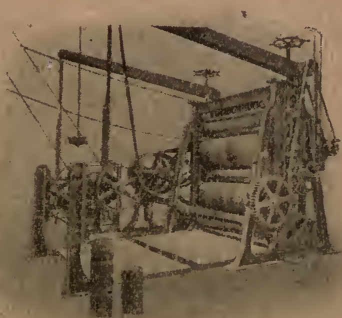


FIG. 67.

through which hessians are next passed before going to the calender. The damping machine is fitted with a box partly filled with water within which a circular brush revolves at a high speed, just touching the surface of the water. The cloth is drawn over the mouth of the box by a pair of rollers. In its progress it is sprinkled by the brush with a fine spray. The cloth is plaited down as it is delivered by the rollers and allowed to lie for some time so that it may become uniformly damp.

Fig. 67 shows the calender through which the cloth is next passed with the object of flattening out the threads, thus closing the interstices of the cloth. At the same time the operation imparts a soft gloss to the cloth appearance. These machines are so heavy that they are usually driven by a separate diagonal engine. The cloth is wound upon a steel roller, which is swung in between two large rollers that revolved alternately backwards and forwards. The friction set up by the heavy pressure employed heats the cloth and flattens the thread so that a glazed finish is given to both sides from the outer to the innermost layer. Three swinging rollers are used to keep the machine in continuous operation, one roller being wound on and another off, while the third is being operated upon. These machines are made wide enough to take two or more pieces side by side, and usually ten minutes is allowed for finishing a roll 100 to 112 yards long.

The calender, being a very heavy machine, should sit upon a bed of concrete at least 12 in. thick. Calenders vary in width from 50 to 170 in., but a 90-in. calender is perhaps the most useful width, as two webs of 40-in. cloth may be finished therein at a time. The machine consists of two very heavy end frames or checks slotted for the bearings of the five rollers or bowls, which may be driven in either direction. Pressure to the extent of one ton for every 4 in. in width is applied by means of levers, racks, pinions and weights. The lowest bowl may be 24 in. diameter and of cast-iron. The next bowl is of compressed paper and about 27 in. in diameter. The central bowl is steam-heated by steam at about 30-lb. pressure per sq. inch. The bowl is hollow, and the condensed water removed by a syphon-pipe controlled by steam trap. Sometimes the heating is done by Bunsen gas-burners, which give a brighter finish. Next comes another paper bowl and another cast-iron bowl similar to those below. The weight of the bowls alone of a 5-bowl 90-in. calender is approximately 6 tons.

Calendering increases the length but diminishes the width of the piece. If the piece is to come out 40 in. wide it must be approximately 43 in. wide in the reed of the loom.

Tarpaulin, bagging and sacking are usually calendered, but hessians are generally chested or mangled.

In chesting, the cloth, after passing through the lower nips, is rolled upon the top bowl, upon which it is subjected to heavy roller pressure for a few minutes.

In mangling, the web of cloth is first beamed hard round an iron roller or "pin" and placed between the bowls of a hydraulic mangle, where the roll of cloth is turned first in one sense and then in the other under great pressure for about a quarter of an hour. A full soft and mellow handle is thereby imparted to the cloth. As the finish largely depends upon the amount of moisture in the cloth, which becomes heated under pressure; the cloth is first damped, then calendered, and finally mangled.

Mangling slightly increases the width of the cloth.

The cloth is wound upon the "pin," for mangling, upon a beaming machine, in which, passing round tension rails, the cloth is lapped upon the pin in a somewhat zigzag fashion at the rate of nearly 70 yards per minute. Creases must be avoided, also the running of the thick selvedges one on top of the other.

In the stone mangle, now little used, the beamed cloth is rolled between the flat surfaces of two heavy stones.

Dundee Public Calenders.—The larger of the Dundee jute mills do their own finishing, but there are also five public calenders that calender, mangle, stiffen and otherwise finish cloth for the local mills, as well as dyeing, cutting-up and making into bags, stamping, baling, and shipping if desired.

After calendering and mangling, the finished cloth, when cool, is measured, folded and baled for shipment.

The measuring and folding machine folds the cloth into laps of given length, which may be counted to ascertain the total length, or their number automatically registered. The piece thus lapped may be rolled and tied up.

The measuring machine used in the jute trade has a measuring roller one yard in circumference, the number of revolutions of which as the cloth passes over it being recorded by a clock or counter. The cloth is drawn through the machine by the nip of a pair of rollers. The machine is also usually fitted with an automatic self-inking marking arrangement, by means of which every yard may be numbered

consecutively and the half-yards marked with a dash if desired.

Although floor-cloth hessians are usually rolled full width, some other makes of wide jute cloth over 50 in. wide, such as packing canvas, &c., are doubled or "crisped" to facilitate packing, &c. In the crisping machine the cloth is doubled selvedge to selvedge along the entire length of the piece. In the crisping machine the cloth is passed full single width over a triangular guide-board, the apex of which causes the cloth to double-over on itself, after which it passes doubled selvedge to selvedge between two angular guides to the fluted drawing-off rollers.

A roy or calanderoy is used for rolling up the cloth either in its full width or crisped or folded in half. It consists of a pair of gables carrying a series of tension rails between them. A short driving shaft carrying fast and loose pulleys is also carried upon one gable and supported at the other side of the pulleys by means of a bracket. The other end of the driving spindle is recessed.

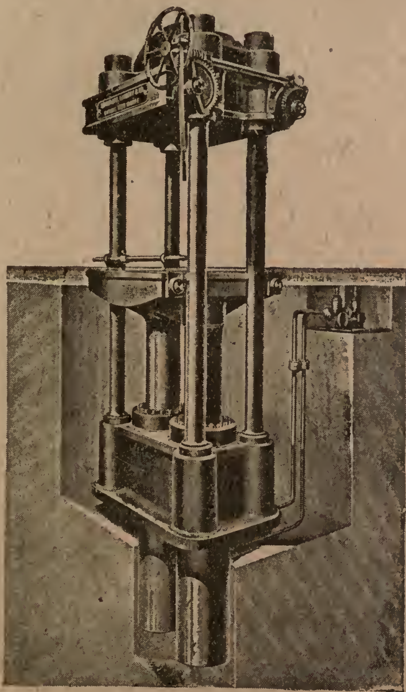
Another method of making up jute goods is upon the lapping machine. In this machine an oscillating knife carries the cloth across the folding table, where the fold is held by a movable grip rail while another fold is made by the returning knife and held in turn by another grip rail upon the table of the machine, which may be either flat, concave or convex. Lapped goods are then folded up and tied, while rolled goods are sewn.

The hydraulic packing press (fig. 68) used to bale goods for export is powerfully constructed and capable of exerting a pressure on the bales of from 10 to 100 tons. The bottom and top boards of the press are slotted so that iron hoops may be passed round the compressed bale, the ends looped, passed through a buckle and fastened by pins through the looped ends.

PRINTING JUTE CLOTH.

The object of printing is either to impress a coloured pattern upon the cloth, as for carpets and matting, or letters and figures, as in sack and bag printing. In the jute carpet trade the old hand-block method still holds sway. The pattern is cut out of wooden blocks like a seal, or may be formed by letting copper wire into the wood to outline the pattern. The colour is mixed with starch and gum to give consistency. Designs of two or more colours require as many blocks as there are colours. The colour paste is spread upon a pad upon which the block is pressed to receive its coating of

colour. To print, the printer places the cloth to be printed upon the table, which must be very smooth and true and



Hydraulic Packing Press.
Hydraulische Ballen-Presse.
Гидравлическій прессъ

Fig. 68.

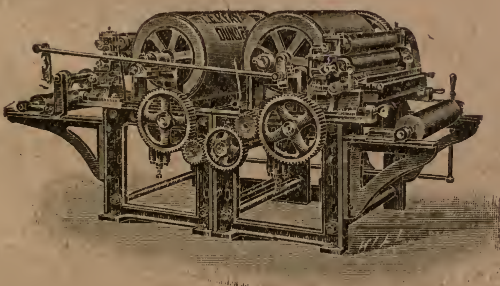


Fig. 69.—Sack printing machine as made by Messrs. T. C. Keay, Ltd., Dundee.

may well be of stone. Having charged the block with colour, he lays it face downwards on the cloth and gives it a tap.

After a moment the block is lifted and a clear impression of the pattern is left upon the cloth.

The sack printing machine prints one or more colours in one operation. It is made in various widths from 32 in. upwards. The printing cylinder is about 22 inches in diameter, and covered with wood staves carrying flexible composition types. It occupies floor space 7 ft. by 3 ft. 6 in., and can print from 1,000 to 1,200 sacks per hour.

The approximate prices charged by the calenderers for various finishes are as follows:—

Cropping Cloth 20 in. wide and under, 1/36d. per yard run; above 20 in. wide, 1/12d. per sq. yard. Goods above 14 oz. and not above 16 oz. per sq. yard, 1/16d. per sq. yard. All goods above 16 oz. per sq. yard, 1/12d. per sq. yard.

Finishing, Calendering or Chesting, including measuring and making up, goods under 18 in., 1/16d. per yard run; from 18 to 24 in., ⅛d. per sq. yard; from 24 to 40 in., 1/12d. per yard run; above 40 in. in proportion to 40 in. rate.

Hessians, if split, 1/9d. per sq. yard for calendering, splitting and making up.

Goods over 84 in. and up to 100 in. wide, calendering and made up, 1d. per sq. yard; over 100 in. wide, by arrangement. Goods over 45 in. and up to 84 in. wide, over 20 oz. per sq. yard, calendered and made up, 1/9d. per sq. yard; over 84 in. wide, by arrangement. Double finish, rate and third.

Goods rolled on boxes, 1/48d. per sq. yard. additional, which will include the charge for stitching; boxes to be supplied by customers. Goods 52 in. wide or over, rolled full width, 1/48d. per sq. yard extra.

American burlaps up to 40 in. wide, uncrisped, whether pieces or cuts, 1/12d. per yard, less 2½ per cent. discount for chesting, making up, and ordinary packing with two hoops and sheet; up to 49 in., in proportion. Burlaps 40 in. wide, weighing over 12 oz., not subject to discount. If bales weigh over 16 cwt. an extra hoop may be put on free. If double finished, rate and a quarter. These special rates to apply where bales contain 2,000 yards or over.

Calendering only, 40 in. and under, 1/18d. per running yard; above 40 in., in proportion to 40 in. rate. When measured, ½d. per cut. Splitting goods, 1d. per split cut, and when measured, ½d. per split cut.

Calendering, measuring, cutting up, and bundling for bags, 1/12d. per yard up to 40 in. wide; above 40 in., in proportion.

Cutting up and bundling for bags, ½d. per yard up to 36 in.; above 36 in., 1/24d. per sq. yard. If tied, 1d. per bundle of

50 bits, or 1½d. per bundle of 100; the charge for tying applies to goods forwarded loose or goods packed. Uncrisping goods, 2d. per cut.

Calendering only, goods over 84 and up to 100 in. wide, 1/12d. per sq. yard; over 100 in. wide, by arrangement. Calendering only, goods over 45 and up to 84 in. wide, over 20 oz. per sq. yard, 1/12d. per sq. yard; over 84 in. wide, by arrangement. Double finish, rate and third.

Real Selvedge Jute Hessian in Narrow Strips.

Chesting, up to 40 in., 1d. per yard; over 40 in., in proportion. Measuring, ½d. per full-width cut. These charges are omitted when goods are received finished.

Splitting, 1d. per cut. Rolling, up to and including 7 yards per end, 1/12d. per split yard; over 7 and up to 15 yards, 1/16d.; over 15 and up to 30 yards, 1/24d.; over 30 yards, 1/30d. Twine, ⅛d. per end. Heavy goods by special arrangement. If P.S. rate and third.

Mangling, including making up: Jute goods, single mangling, 1/7d. per running yard. Jute goods, double mangling, 1/5 per running yard up to 36 in. wide; above 36 in. wide, 1/5d. per sq. yard. Patent selvedge jute hessians, single mangling, splitting, and making up, ⅙d. per sq. yard; double mangling, splitting, and making up, ¼d. per sq. yard. Hessians or other jute goods over 16 porter to be charged as linens. Other goods under 18 in. wide, 1/7d. per running yard; above 36 in., ¼d. per sq. yard. On goods received calendered no allowance can be made.

Goods sent out not made up, one-sixth less. Goods returned in mill fold, 1d. per piece or cut. If crisped, 1½d. per cut; if measured, ½d. per cut.

All goods 25 in. and up to 60 in. wide to be charged rate and quarter; above 60 in., rate and half. Goods made up book fold or if with cross twine, rate and half. Creas, &c., under 65 yards, stitched with twine and silk, 4d. per cut; over 65 yards, 6d. Twice-crisped goods to be charged double for twine. Jute bagging, &c., twice crisped to be charged net, both for finishing and twine. Pressing, ¼d. per cut. Two fancy slips, ¼d. extra per cut; if over 30 yards, ½d.

JUTE BAG MAKING.

In the manufacture of sacks from piece goods the cloth is first cut into lengths upon the sack-cutting machine which,

if upon Blythe's hand principle, will cut up to ten thicknesses of cloth at one operation. Parker's machine has a cylinder 6 ft. × 14 in. diameter or 42 in. in circumerence. The length of the knife is 6 ft., and of first board 15 in., and of back or table board 18 in. Only one piece is cut at a time but in rapid succession.

The smaller-sized bags are sometimes woven tubular with a double set of heddles, four or more threads per split of reed, and two webs—an upper and a lower—joined together at both sizes. The tube when finished may be cut into suitable lengths and sewed top and bottom. Or the bottom may be formed by running the two webs into one at stated intervals for an inch or so, then cutting the web up just under or behind this portion, so that only the tops are sewn. Or again, complete bags may be made in the loom by running the two webs together at intervals for the side seams and leaving two selvedges unjoined at one side of the loom for the mouth of the bag, the bottom being continuous.

Not so very long ago bags were all hand-sewn. Then the lock-stitch machine was introduced to stitch in the raw edges of the bag's mouth or to make a seam along the sides or bottom. Later the overhead stitch of the hand-sewer was accomplished by machinery. Now only the very heaviest type of bag is hand-sewn, and that by outworkers as a rule. If the bag is made from the width of the cloth, one selvedge forms the top and the bottom and one side must be seamed. To allow for the roll of an overhead seam the cloth must be ½ in. wider than the depth of the bag. In cutting the cloth into lengths for the round of the bag 2½ in. must be allowed for the roll of the overhead side seam. Or again, the bag may be made with the raw edges at the top and bottom of the bag and the two selvedges together at the side seam. Or again, the cloth may be cut double the depth of the bag and woven only slightly wider than the bag so that the selvedges may be sewn together at both sides. The top hems are made about ⅝ in. wide, and are arranged to lie upon the outside of the bag.

Two threads are, of course, required for the lock-stitch machine, the top thread being carried through the plies of the cloth by the needle and is then slackened into a loop under the fabric so that the shuttle or bottom thread may be carried through. The needle is then raised, drawing the top thread tight and carrying with it the bottom thread into the centre of the work. The accuracy with which this is accomplished

depends upon the proper tensioning of both threads. The lower or shuttle thread is wound in the form of a cop 2½ in. long by ⅞ in. diameter. The lock-stitch machine is comparatively slow and the shuttle thread must be frequently replaced. The Union or Yankee machine, however, makes up to 2,000 stitches per minute, and has seldom to be stopped as both threads are carried in large rolls of cheeses and can be used for both hemming and seaming. The stitch, however, is more of a chain than a lock stitch.

Laing's machine makes an overhead stitch and is greatly used for heavy work. For this machine the threads are cut to double the length for each seam, being doubled in two, and the bight placed on the hook of the needle, which rotates spirally round the needle tube through which the doubled-over seam passes.

The standard size of the Australian wheat bag has a

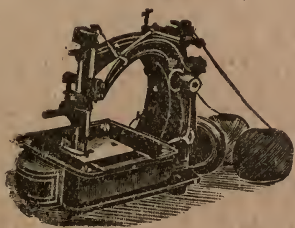


FIG. 70.—Sack-sewing machine.

capacity of 200 lb. of grain. Bags as made in Dundee vary in size from cotton packs 45 in. by 85 in. and 30 in. by 60 in. grain sacks to 16 in. by 24 in. mail bags. Sand bags are 14 in. by 33 in. in size.

SACK SEWING TARIFF—LESS 3 PER CENT.

Note.—In calculating prices 0·01 to 0·49 inclusive will be in favour of the customer, but 0·50 to 0·99 will be in favour of the calenderer.

OVERHEAD SEAM, JUTE TWINE—BY MACHINE.

Hessian up to 14 oz., 40 in., 3s. 2d. per 10,000 in.; above 14 oz., 40 in., 3s. 4d.

Bagging under 20 oz., 42 in., 3s. 5d. per 10,000 in.; 20 oz. to 24 oz., 42 in., 3s. 8d.; for every ounce or part of an ounce above 12 ounces, 1d. additional.

Bagging and twilled woolpacks, with jute twine, 5s. 6d. per 10,000 in.

Twilled tarpaulin or bagging bags under 60 in. of sewing, 5s. 11d. per 10,000 in.; but if laid in at bottom as well as side, 6s. 2d. If safety seam sewed, 2s. 1d. per 100 bags extra.

Tarpaulin up to 18 oz., 45 in., 3s. 4d. per 10,000 in.; above 18 oz. up to 20 oz., 45 in., 3s. 7d.; for each oz. or part of an oz. above 20 oz., 1d. additional.

Bags, overhead seam, laid in both sides, or side and bottom, 7d. per 10,000 in. extra.

Hop pockets, unhemmed ex 24-oz. cloth, sewed with ordinary hemp twine, 11s. 7d. per 100; ex 28-oz. cloth, 12s. 9d. per 100; and all turning of hop pockets to be ½d. each, and all above 28-oz. to be charged 3d. per oz. additional. In Italian hemp twine, 3s. 8d. per 100 extra.

Cop bags, not less than 1⅛d. each, without handles; with handles, 1½d. each; if with eyelets, ⅛d. per hole additional.

For all foregoing, hemming one-half.

Overhead Seam, Jute Twine—By Hand.

(3 to 4 Stitches per Inch.)

Hessian up to 12½ oz., 40 in., 6s. 1d. per 10,000 in.; over 12½ oz., 40 in., 1d. additional for each oz. or part of an oz.; over 4 stitches per inch, 6d. per 10,000 in. additional. Hemming, one-half.

Pig wrappers, with 14 eyelets, 7s. per 100; with 16 eyelets, 7s. 7d.; with 18 eyelets, 8s. 3d.; with 20 eyelets, 8s. 9d.; if above 10 oz., 40 in., 1d. per 100 wrappers for each additional oz. Supplying and inserting brass eyelets, up to size 24, ¼d. each; up to size 27, ⅜d. each; up to size 30, ½d. each. Tabs and rings not less than ¾d. each.

Canvas ore bags sewed with flax twine, 1 2/12d. per 100 in. of actual seam; if twine left at mouth, 2d. per 100 bags to be added.

Dowlas, sheeting, and seed bags, not less than 6s. 9d. rate; hemming, one-half; small quantities and sizes, usual extra; no bags of this description to be sewed under 3s. per 100.

Hemp twine, 1s. 3d. per 10,000 in. additional to rates for jute.

Sacks sewed with hemp waster, 2s. 5d. per 10,000 in. additional to jute.

Hand-sewing twills, baggings, tarpaulins, &c., jute twine, 8s. 3d. per 10,000 in.; ordinary hemp twine, 9s. 6d. per

10,000 in.; if hemp waster, 10s. 8d. per 10,000 in. Hemming to count one-half.

Double hand-sewing bagging, sacking, tarpaulin, and T.W. hessians, 1¼d. per 100 in. of single seam. Hemming to count one-third.

Union Seam, Flax Twine.

Hessian up to 14 oz., 40 in., 4-5 stitches, 2s. 6d. per 10,000 in.; 5-6 stitches, 2s. 10d.; 6-7 stitches, 3s. 3d. Hessian above 14 oz., 40 in., light bagging, tarpaulin, &c., 4-5 stitches, 2s. 10d. per 10,000 in.; 5-6 stitches, 3s. 2d.; 6-7 stitches, 3s. 7d. Hemming one-half. Double sewing unhemmed bags, rate and two-thirds. Double sewing hemmed bags, rate and half.

Biscuit bagging up to and including 4 oz., 40 in., double rate; above 4 oz., 40 in., and up to and including 6 oz., 40 in., rate and half.

Round bottom bags to be full tariff rates and 4s. 3d. per 100 extra; thus, 19 by 84 ex 39-in. cloth would be 7s. 9d. per 100.

Yeast bags up to 12 by 16 single seam, 1s. 3d. per 100; if with round bottoms, single seam, 2s. 1d. per 100.

Double Seam (One-half Machine Flax Twine, One-half Hand, or Overhead Machine Jute Twine).

Hessian up to 12 oz., 40 in., 6s. 5d. per 10,000 in.; tarpaulins up to 20 oz., 45 in.; baggings up to 22 oz., 45 in.; and sackings up to 17 oz., 27 in., 6s. 10d. per 10,000 in.; 1d. additional for each half-ounce or part of half-ounce over the above weights. Hemming, one-third. Hemp or flax twine, 1s. 3d. per 10,000 in. additional.

Yeast bags up to 11 by 16, 3s. 1d. per 100; yeast bags, square bottoms, double needle sewed, 9¼ by 13½, 1s. 6d. per 100; 11 by 16, 1s. 7d. Yeast bags, double seam, up to and including 9½ by 13½ may be done at 2s. 11d.; above that size rate must be 3s. 1d. per 100.

Safety Seam.

Overhead and union seam rates, added together.

Hemming to be reckoned separately at one-half of overhead rate.

Sacking, bagging, tarpaulin, &c., bags, safety seam, heavy jute twine or heavy flax twine, to be not less than 4s. 9d. per 10,000 in.; the overhead sewing and hemming to be charged at usual rates.

General.

Lugs stitched across bottom corners, 1s. 4d. per 100 bags.

Twine attached to mouth of bags, 1s. 3d. per 100 bags, and the cost of twine additional.

Bags under 60 in. of sewing (except twilled, tarpaulin, or bagging bags, by overhead machine), or lots of less than 200 bags to be charged extra, but not less than 6d. additional to above rates per 10,000 in., or as 60 in. and 200 respectively.

No bags to be sewed under 1s. 3d. per 100.

Hemming only, 2s. 7d. per 10,000 in.

Double bags to be charged as separate bags, and 1/12d. per bag additional for putting one inside the other.

Double bags hemmed together, the sewing and hemming to be charged as two separate bags.

Linen bags, except paper lined, to be charged double rates; that is, where the cloths are sewn at one operation.

Hessian woolpacks, 5s. per 10,000 in. for overhead seams.

Stitching hessian with jute twine or heavy flax twine, not less than 3s. 9d. per 10,000 ins.; hessian, 14 oz., 40 in. or over, and other heavy goods, not less than 4s. Hemming one-third.

Sewing ore bags T seam, up to 12 by 20 in., 11/16d. per bag; from 12 by 20 to 16 by 24, ¾d. per bag; above 16 by 24, 1d. per bag; if not sewn at mouth and string left, 6d. per 100 less.

Twilled woolpacks, or sheets, &c., sewn with gill seam, such felling to be charged 2s. 10d. per 10,000 in. All bags sewn with tarred or dyed twine, 3d. per 10,000 in. extra.

Unrolling or running down Calcutta or other goods previous to sewing, 1d. per cut of 100 yards. It is recommended that for cutting of bags 2½ in. at least must be allowed upon all tarpaulin, bagging, and sacking up to 19/27; if above that weight, 3 in. With hessian 6 oz., 40 in. and under, 4 to 5 in. should be allowed.

BLEACHING AND DYEING.

Jute yarns and cloth are seldom bleached, the process being expensive, destructive to the fibre, and seldom gives a satisfactory white. The loss in weight varies from 5 to 20 per cent. of the original weight. When under treatment with chlorine, chlorine derivatives are formed, which, although white at first, acquire a yellow or brownish tinge when subsequently washed and treated with acids or alkalis, while at the same time the fibre becomes rotten. Under these circum-

stances it is impossible to bleach jute by the same process as that adopted for linen.

The bleaching of jute yarns is facilitated by the saponification of the batching oil contained in it by the addition of soft soap or alkali. The larger the quantity of mineral oil in the batching liquor the larger the quantity of alkali required. If soap be used, about 4 per cent. per gallon of oil will be found sufficient. One per cent. of caustic soda will have a like effect.

Creamed jute cloth required for printing should be impregnated with a solution of bisulphide of soda of such strength as to contain 7 to 2 per cent. of sulphuric acid, and then dried on steam cylinders.

Jute yarns and cloth take ordinary cotton dyes easily and well. The boiling dye bath should contain about 18 per cent. of Glauber's or common salt. After treatment with copper sulphate improves their fastness to light considerably. For full details *re* jute bleaching and dyeing see our book, "Bleaching and Dyeing Flax and Jute Yarns and Fabrics," 3s. 6d. post free.

Jute Paddings and P.S. Hessians, 24 in. up to 30 in.

Dyeing black, soft finishing, no addition to weight, up to 8 oz., 24 in., 5/16d. per running yard, 24 in. wide; above 8 and up to 11 oz., 24 in., $\frac{3}{8}$d. per running yard, 24 in. wide; above 11 oz., 24 in., 7/16d. per running yard, 24 in. wide. If any addition is made to weight by whatever process, $\frac{1}{8}$d. per running yard, 24 in. wide, to be added to above rates for each ounce or part of an ounce; if over 3 oz. added, double rates to be charged for each oz. after the 3 oz. If split, 1d. per split cut to be charged additional. If above 24 in. wide, in proportion.

Jute Baggings, Pocketings, Tarpaulins, &c., up to 24-42 in.

Dyeing black and making up only, 8/12d. per lb. grey weight; dyeing black and soft finishing, $\frac{3}{4}$d. per lb. grey weight. If starched, $\frac{1}{8}$d. per yard for each ounce or part of an ounce added; goods over 36in. wide, minimum rate for starching, $\frac{1}{4}$d. Stiffened goods, if lapped, 1/24d. per sq. yard additional. If goods finished before dyeing, 1/24d. per yard additional to be charged up to 40 in. wide; above, in proportion.

Jute Hessian up to 54 in. Wide.

Dyeing black and making up only, ¾d. per lb. grey weight; dyeing black and soft finishing, no weight added, 25/32d. per lb. grey weight. If starched, ⅛d. per yard for each ounce or part of an ounce added; goods over 36 in. wide, minimum rate for starching, ¼d.

Hessians, scrims, &c., up to 5½ oz., 40 in., black and soft finishing, 1¼d. per lb. grey weight. Hessians, scrims, &c., above 5½ oz., 40 in., up to and including 7½ oz., 40 in., to be charged at 5/12d. per yard 40 in. wide and other widths in proportion. Stiffened goods, if lapped, 1/24d. per sq. yard additional.

If goods finished before dyeing, 1/24d. per yard additional to be charged up to 40 in. wide; above, in proportion. Goods over 54 in. wide, ⅞d. and 15/16d. respectively.

Tow Warp and Jute Weft Paddings, 24 in. up to 54 in. Wide.

Dyeing black, 1¼d. grey weight.

Cotton Warp and Jute Weft Padding.

Dyeing black, 1½d. per lb. grey weight; for every ounce required to be added ⅛d. additional per yard. Finishing to be charged additional as follows: Calendering, ⅛d. per running yard up to 36 in.; above, .per sq. yard. Mangling, up to 25 in., ¼d. per running yard; 26 in. and up to 36 in., 5/16d. per running yard; above 36 in., 15/16d. per sq. yard. Stiffened goods, if lapped, 1/24d. per sq. yard additional.

Fancy Dyeing.

Jute Goods.—Tan brown (including soft finishing), 1¼d. per lb. grey weight. All weights up to 8 oz., 40 in., to be charged not less than ⅝d. per yard 40 in. wide; other widths in proportion. Tan brown, if slightly stiffened, ½d. per lb. additional; tan brown, if hard stiffened, ⅝d. per lb. additional. Other fancy colours (including soft finishing), 1½d. per lb. grey weight. If bleached shades, 2½d. per lb. grey weight.

Creaming or bleaching, including double chest finishing, 1½d. per lb. grey weight. Drying hessians, ⅛d. per yard up to 40 in.; above 40 in., in proportion. Drying tarpaulin, bagging, sacking, &c., ¼d. per yard up to 40 in.; above 40 in., in proportion.

Jute Paddings, Hessians, 24 in., up to 30 in.

Stiffened and finished, adding up to 4 oz. on 24 in., 5/16d. per yard 24 in. wide; adding over 4 oz. on 24 in., ⅜d. per yard, 24 in. wide. If above 24 in. wide, in proportion. Splitting to be charged 1d. per split cut extra. If lapped, 1/24d. per sq. yard additional. If crisped, 2d. additional per end or 4d. per cut of 100 yards.

Hessians, Buckrams, &c., above 30 in. up to 54 in. Wide, Finished or Unfinished.

Starching, adding 2 oz. per sq. yard, ⅝d. per sq. yard; adding up to 6 oz. per sq. yard, 15/16d. per sq. yard; adding above 6 oz. per sq. yard, 1⅛d. per sq. yard. If above 18 oz., 40 in., extra to be charged. Bagging and tarpaulin, ⅛d. per sq. yard additional. If crisped, 2d. additional per end, or 4d. per cut of 100 yards. If lapped, 1/24d. per sq. yard additional. Collar canvas, starched only, ducks and hessians, 1½d. per sq. yard. Heavy goods, 1¾d. per sq. yard.

Gum Finishing.—Hessian up to 14 oz., 40 in., 2½d. per sq. yard; if above, 3d. per yard. Sacking or bagging, 3½d. per sq. yard. Sackings to be charged 1/12d. per sq. yard extra for rolling. If black, dyeing to be charged extra at tariff rates.

Glue Finishing Hessian, 2½d. per sq. yard. Sacking, 3d. per sq. yard. If black, dyeing to be charged extra at tariff rates.

General.

Should goods be received crisped or rolled, either for dyeing or starching, a charge of 3d. per cut of 100 yards is made for unrolling and crisping.

Jute tarpaulin may be proofed with one of the following liquid pastes: (1) 5 parts of Stockholm tar pitch melted with 4 of resin and 1 of Stockholm tar; (2) 48 parts of Stockholm tar pitch, 10 Stockholm tar, 32 resin and 1 tallow. These mixtures should be applied to the surface of the cloth while hot. Pure pitch may also be applied hot by pouring it over the cloth and spreading it with a hard brush, or a machine may be used in which the cloth is drawn slowly over a flat table upon which the pitch falls, the spreading being done by fixed doctor knives or brushes. Squeezing rollers may also be used in such a machine. The heated cloth is dried over drying cans, or hung up in a heated chamber.

Tarpaulin may also be waterproofed by applying a thin

coating of boiled tar. For general purposes, the tar is painted over one side only, but heavy tarpaulins are coated on both faces. The tar must be applied as hot as possible, and it is advantageous to have the canvas heated over a metal plate kept warm with steam or metal heaters. The cloth is wound tightly or a large roller and the portion under treatment is pulled over the hot plate. The tar is discharged over a pair of small rollers that spread it, or it may be painted on to the stretched fabric by two workmen, one on each side of the sheet, who apply a thin coating over half the width of the fabric. They hold a brush in one hand and a flat rule in the other to strike off the superfluous tar and distribute the layers more evenly over the surface. As soon as the tarpaulin is coated it is hung up for some time in a well-ventilated shed in order that certain of the volatile matters may be given off and the material lose its pungent smell. After seasoning it may be rolled up or folded for use, but it is dangerous to fold together freshly made tarpaulins, as in this condition they are liable to heat and might even occasion spontaneous combustion. The coating with tar is usually carried on separately by an outside firm. Tarpaulin is made in widths of from 36 to 50 in.

Floorcloth is composed of a foundation of jute hessian, which, after being sized and rubbed smooth and even, is coated with a mixture of ochre, linseed oil and benzine. The surplus material is scraped off by revolving metal blades, and when dry the coating is rubbed smooth with pumice stone. The coating and rubbing are repeated until the desired thickness is attained. The pattern is printed on by hand or machinery. In printing by machinery the cloth passes over a flat table and under wooden blocks, which rise and fall. The colour is applied to the block when in the raised position by a roller. After printing and drying, the surface is varnished and the cloth trimmed and rolled up ready for market.

Linoleum is likewise composed of a foundation of jute hessian, on which is fastened evenly and thoroughly a cement composed of solidified linseed oil mixed with cork, kauri gum, resin and pigments.

Granite Linoleum.—Besides the plain, printed and inlaid linoleum described, there are others. Granite linoleum is made with pastes containing masses or spots of different colours. The colours remain separate in the completed fabric, but the assemblage and relation of these variously coloured spots and masses are casual. Plank linoleums, oak plank linoleums, or

plank inlaid linoleums, are made by running upon the burlap paste of two colours in equal stripes, the materials being kept from mixing and the effect somewhat resembling a floor inlaid with alternate planks of different woods. The pastes are pressed into and firmly united with the cloth by hot rollers. In some cases the pattern is painted on with the aid of stencils instead of by printing rollers.

APPENDIX.

DUNDEE'S JUTE INDUSTRY.

When it was ascertained in the forties of the last century that Indian jute fibre could be cheaply spun into yarn and woven into cloth, it was in Dundee that the ingenuity and enterprise were found which turned the discovery to commercial use. The city became the centre of the industry in the United Kingdom and from that position it has never been dislodged. Indeed it has now a monopoly of the industry in this country, practically all the raw jute imported into the country, averaging 1,200,000 bales annually, being spun in Dundee and district. The trade, which is the staple one of the city, employs about 35,000 workers.

The chief products are yarns, hessian cloth, D.W. bagging and tarpaulin, twilled sacking and sacks, bags and covers made therefrom. But there are other purposes for which jute can be utilized and these have been skilfully developed in Dundee. Jute, it was found, could be easily dyed in the most delicate shades, and this led to its use in carpeting. The price at which jute carpets could be sold gave a great impetus both to the importation of the raw material and to the exportation of jute twist and yarns.

Another important development was the use of wide widths of hessian cloth as the foundation of linoleum, the manufacture of which has made extraordinary progress in this country as well as on the Continent and in the United States of America. The successful application again of jute cloth to coffee bagging displaced flax-tow bags, and this provided another profitable production for Dundee. It is impossible, indeed, to enumerate all the fabrics made in the city, but in addition to those mentioned there is manufactured a great variety of plain and figured fabrics of all colours for wall, stair and floor covering, as well as millions of wrappers and bags of all kinds and sizes used in transporting and storing various kinds of merchandise. Indeed the jute trade has ever been on the alert to seize all opportunities that presented themselves for directing the industry into new and remunerative channels, and it is due to this enterprise, coupled with the inherent skill of textile operatives in general, that the prestige of Dundee in the jute trade has been maintained in spite of the worldwide competition with which it has in recent years been faced. It is nothing short of a marvel that the

city should hold a supreme position in an industry every ounce of the raw material of which has been brought from thousands of miles overseas and the markets for products of which had to be found in every part of the globe.

The part which the jute industry played in providing sandbags for our armies during the war was a remarkable one. When the order came from London, within the short space of a fortnight the enormous amount of 150 million sandbags were sent out from Dundee.

DUNDEE-CALCUTTA JUTE COMPANIES.

The Indian jute trade has provided a profitable outlet for Dundee's surplus capital. Three of the leading Calcutta jute companies, the Samnuggar, Titaghar and Victoria, have been financed from Dundee. The dividends paid in 1919 were respectively 50, 70 and 60 per cent. As it will be seen from the subjoined table, there has been an appreciation of over 100 per cent. on the market price of the ordinary shares of the companies.

	1919 Nominal value	1919 Market value	Increase	Decrease
(1) The Samnuggar Jute Factory Co., Ltd., 15,000 5 per cent. cum. pref. shares of £10 each	£150,000	£135,000		£15,000
30,000 ord. shares of £10 each	300,000	855,000	£555,000	
(2) Debentures and loans	127,563	127,563		
Titaghar Jute Factory Co., Ltd., 15,000 5 per cent. cum. pref. shares of £10 each	150,000	135,000		15,000
30,000 ord. shares of £10 each	300,000	900,000	600,000	
Debentures and loans	69,156	69,156		
(3) The Victoria Jute Co., Ltd., 15,000 5 per cent. pref. shares of £10 each	150.000	135,000		15,000
20,000 ord. shares at £10 each	200,000	270,000	370,000	
Temporary loans	232,600	232,600		
	£1,469,979	£2,949,979	£1,525,000	£45,000

A BENGAL VILLAGE INDUSTRY.

An industry, which has an importance all its own, is carried on in many villages in the districts of Tippera, Dacca, Bakargang and Pabna by a class of men known as "*Kapales.*" These people twist jute twine by hand and weave gunny

cloth with it in a very crude and laborious process. These products are better than mill-made gunnies, but dearer as a rule. Efforts are being made to introduce a simple machine for twisting the thread and the fly-shuttle loom for weaving the gunny.

SCOTTISH TRADE ASSOCIATIONS.

Association of Dundee Public Calenderers; Secretary: J. G. Kenmond, Trades Lane Calender Works. Association of Dundee Public Dyers (same secretary). Association of Jute Spinners and Manufacturers; Secretary: F. S. Cathro, 1, Royal Exchange Place, Dundee. Dundee Jute and Linen Goods Merchants' Association; Secretary: Geo. R. Donald, 3, Bank Street, Dundee. Jute Importers' Mutual Protection Association; Secretary: Jas. L. Peter, 23, Penmure Street, Dundee. Scottish Flax Spinners' and Manufacturers' Association; Secretaries: J. and H. Pattulo and Donald, 1, Bank Street, Dundee. Scottish Yarn Bleachers' Association; Secretary: Geo. Webster, Rothesfield, Markinch.

JUTE BAG AND SACK EXPORTS.

	1913 dozens	1918 dozens
To Russia	82,225	Nil.
,, Sweden	131,888	,,
,, Denmark	125,200	2.517
,, Germany	475,158	Nil.
,, Holland	206,001	2,500
,, Belgium	262,567	Nil.
,, Austria-Hungary	61,375	,,
,, Turkey	87,891	,,
,, United States	278 955	15,022
,, Guatemala	71,673	13,517
,, Chili	110,189	27,835
,, Argentine	1,132.584	8,640
,, Canada	207,104	28.387
,, British West Indies and Guiana	26,501	5,167
,, Other countries	1,195,712	801,029
Total	4,543.123	904,614
Total declared value	£1,224,675	£677,146

JUTE YARN EXPORTS.

	1913 lb.	1918 lb.
To Germany	706,100	Nil.
,, Spain and Canaries	272,900	140,000
,, United States	306,100	46,200
,, Brazil	14.529,600	1,337,300
,, Other countries	25,801.400	4,254,100
Total	41.706,100	5,777,600
Total declared value	£780,988	£220,870

JUTE MANUFACTURES (Except Bags).

	1913 yards		1918 yards
To Germany	1,245,000	...	Nil.
,, France	301,000	...	2,657,200
,, United States	90,355,600	...	19,005,300
,, Brazil	722,200	...	30,200
,, Argentine...	12,978,500	...	1,162,500
,, Australia	4,689,000	...	890 100
,, New Zealand	2,277 900	...	347,700
,, Canada	23,120,000	...	3,120,000
,, Other countries	37,793,800	...	4,402,900
Total	173,484,200	...	31,615,900
Total declared value ...	£3,066,084	...	£1,088,785

HEART DAMAGE.

The so-called heart damage of baled jute is due to the development, with subsequent degradation of the cellulose constituent of the attacked fibres, of thermophilic bacteria in the moist material. The more tightly the material is packed, the lower the proportion of water required for the development of the organism.

SOME INDIAN JUTE MILLS.

Most of the Indian jute mills are situated on the banks of the river Hooghly and erected on the shed principle, being situated in spacious compounds or enclosures with fine river frontages. The Victoria Mill, for instance, has a compound of about 40 acres. In pre-war days new mills cost about £270 per loom to erect and start. The Hastings Mill (Messrs. Birkmyre) is one of the best equipped of the Calcutta jute mills. Its nucleus consisted of old machinery brought out from Gourock by its far-sighted proprietors nearly half a century ago. The old machinery has long since disappeared and it is now a magnificent property of over 500 looms and employing 4,000 hands. The ground on which it stands was originally the place where Warren Hastings had his country seat, hence the name. The old country seat still stands and is used as a dwelling house for the European assistants at Wellington Mill close by. The mills are wrought upon the shift principle, but no individual woman or child works more hours per week than the corresponding class of worker does in Dundee. The looms are all worked by men—one man, one loom.

In pre-war days when working full time the mill engines went from daylight to dark during six days of the week, Sunday being occupied with cleaning and repairing machinery.

The wages of preparing hands range from 1s. 3d. to 2s. 3d. per seventy-two hours' week. Cutters earned 2s. 9d. per

week, and spinners 2s. 5d. Shifters averaged 1s. per week. Native foremen, or sirdars, earned from 3s. 9d. to 6s. 6d. per week. Weavers averaged 4s. 2d. per week, and tenters 7s. The workers are nimble and expert. The wages earned seem low compared with Dundee rates, but the cost of living is also very low and Indian workers are very frugal. Their food consists of rice, fruit, vegetables, with fish occasionally, and sometimes the flesh of the goat which has been killed as a sacrifice. The Mohammedan workers are flesh eaters. Milk forms a great staple of diet with all classes. The great annual holidays are at the time of the Doorgah Poojah Festival, about the beginning of October, when the works are generally closed for a week.

The workers live in huts made of dried clay with thatched roofs. At some of the mills, the owners have erected long lines of these huts in parallel rows, taking every precaution possible regarding sanitation. At Champdany Mill, for instance, a regular staff of scavengers is employed to keep the lines clean. The native fuel for cooking is cow dung. This is carefully collected, made into cakes, and stuck upon the outside walls of their huts to dry, after which it makes very efficient "native peats." The workers are quiet, peaceable and docile beings.

The manufacturing cost per ton of hessian cloth for the American market in Calcutta was approximately £7.

The Serajgunge Mill is at Serajgunge, 150 miles from Calcutta.

The Chittavalsah Mill is at Ganjam, in the Presidency of Madras.

There is a mill at Cawnpore, 600 miles from Calcutta.

The Budge-Budge Mill lies about 12 miles below and the Gourepore about 28 miles above Calcutta, and the others are located between them. Nearly all the mills on the left bank of the Hooghly have sidings connecting them with the the Eastern Bengal State Railway, and those on the right bank are similarly situated with regard to the East Indian Railway.

These two railways are connected by the Jubilee Bridge at Naihati, close to Gourepore and just above Chandernagore. The State Railway is connected with the jute district.

Mills on the shed system have the roof supported by iron columns about 20 feet high and girders. The buildings are thus very lofty. The whole building averages about 450 feet long by 300 feet wide, occupies approximately 3 acres of floor surface and is entirely open from end to end. Rows of skylights and ventilators are let in at intervals in the roof, and the buildings are generally exceptionally well lighted and ventilated, every effort being made to keep the temperature

uniform. Floors are usually of teak or of asphalt. On the average there are about 650 native hands per 100 looms, including all departments. About 20 spinning spindles per loom are required.

The Wellington Mill, now forming a branch of the Champdany Company, was originally started in 1855 by Mr. George Acland, a Devonshire man, as a jute spinning mill only. In 1858 it was burned down, but restarted, with a factory containing about 100 looms, as the Ischera Yarn Mills Co., Ltd. In 1868 it came to grief and was sold by auction to Messrs. Barrodaile, Schiller and Co., who launched it on the market as the Calcutta Jute Mills Co., Ltd., after having overhauled the machinery and increased the number of looms to 260. In 1877 it again collapsed and the agency passed into the hands of Messrs. A. R. M'Intosh and Co. In 1880 it again became bankrupt, and in 1881 it was taken over by the Champdany Co., owned by Messrs. Finlay, Muir and Co., of Glasgow and Calcutta, and re-christened the "Wellington." It now contains 277 looms and 1,248 spindles.

The Barnagore Mills were originally started in 1857 as the Borneo Company by Messrs. George Henderson and Co., of London and Calcutta, and originally contained 520 looms. In 1874 it was converted into a limited liability company under its present name. They now contain 634 looms and 14,136 spindles.

The Gourepore Mill was started in 1862 by Messrs. J. B. and T. Barry, who were Irishmen. For some years the agency was held by Messrs. Jardine, Skinner and Co., but in 1877 was transferred to Messrs. Barry and Co. The mill originally contained 160 looms but has now 415 looms and 8,176 spindles.

The India Mill was commenced in 1868 by Messrs. Mackinnon, Mackenzie and Co., of Glasgow. The original number of looms was 200 and is now 300, with 6,000 spindles.

The Alipore Jail Mill, containing 130 looms and 2,340 spindles, is worked by the convicts in the Calcutta Central Jail, and appears to have been in existence since 1876.

The Chittavalsah Mill at Gamjam, Madras, has 100 looms and 1,800 spindles.

The Cawnpore Jute Mill, at Cawnpore, is managed by Messrs. Beer Bros. of that city, and contains 75 looms and 1,600 spindles.

The Chandernagore Mill was floated in 1892 by Messrs. Gillanders, Arbuthnot and Co., and in order to have the support of the French Government a registered office was opened in Paris.

The Serajgunge Mill, built in 1864 by Messrs. Hoare, Miller and Co., of London and Calcutta, has now at least 310 looms and 6,000 spindles.

The Fort Gloster Mill was started in 1872 by Mr. Richard Macallister, an American. It came to grief in 1879, and then passed into the hands of Messrs. Kettlewell, Bullen and Co. There are now 356 looms and 5,700 spindles.

The Champdany Company was floated in 1873 by Messrs. Finlay, Muir and Co., of Glasgow and Calcutta. It contains 368 looms and 6,568 spindles.

The Union Mill was originally launched by Mr. Richard Macallister, of the Oriental Jute Co., Ltd., the original building being a goods depot. Coming to grief in 1878, Mr. Henry S. Cox, of Dundee, took over the agency and the Company made a big loss and came to grief next year, when the agency passed into the hands of Messrs. Bird and Co., who reduced the capital by one-half. It contains 351 looms and 6,568 spindles.

The Barnagore Branch Mill was originally started in 1874 by Messrs. Schoene, Kilburn and Co., of London and Calcutta, as the Bengal Jute Pressing and Manufacturing Co. It commenced operations with 72 looms in an old jute press-house, but came to grief three years later. It was restarted as the Ballinghatta Co., Ltd., with 100 looms under the agency of Messrs. Gillanders, Arbuthnot and Co., of London and Calcutta, but again collapsed and was taken over in 1881 by the Barnagore Co. It contains 165 looms and 3,776 spindles.

The Budge-Budge Mill was started in 1874 with 150 looms by Messrs. Andrew Yule and Co., of London and Calcutta, and has been most successful. It now contains 460 looms and 8,784 spindles.

The Soorah Mill was started in 1874 as the Asiatic Jute Co. by Messrs. Cohen Bros. and Co., of Calcutta, with 70 looms. In 1878 it passed into the hands of Messrs. Rushton Bros., and finally, about 1884, was bought by Baboo Budrudoss Rampershad. It contains 140 looms and about 3,000 spindles.

The Seebpore Mill was started in 1874 by Messrs. Apear and Co., of Calcutta, with 250 looms, now increased to 450 and 9,000 spindles.

The Howrah Mill was started in 1874 by Messrs. Ernsthausen and Oesterley, of Calcutta, and originally contained 275 looms, since increased to 561, with 10,644 spindles. Agents, Messrs. Ernsthausen and Co.

The Clive Mill was started in 1874 by Messrs. Gladstone, Wyllie and Co., of Liverpool and Calcutta, with 140 looms, now increased to 162, and 3,500 spindles.

The Samnuggar Mill was started in 1874 with 313 looms, and Messrs. Schoene, Kilburn and Co., agents, and was really the first Dundee concern. In 1884 Messrs. Thos. Duff and Co. took over the agency. It now contains 560 looms and 12,600 spindles.

The Ganges Mill was started in 1875 by Messrs. M'Neill and Co., of Calcutta, with 300 looms. Its capital is held chiefly in Glasgow and in London. It now contains 1,667 looms and 8,564 spindles.

The Hastings Mill was started in 1875 with 230 looms by Messrs. Birkmyre Bros., of Gourock and Calcutta. It is a private concern and now contains 1,559 looms and 10,500 spindles. Their manufactures have a high place in the Indian market, as they always buy the best jute available early in the season.

The Central Mill was originally launched in 1875 by the American, Mr. R. Macallister, as the Rastomjee Twine and Canvas Factory Co., Ltd. This not proving a success, the concern was converted into a jute mill with 125 looms, but again came to grief. In 1880 it was restarted as the Goosery Jute Mills and enlarged to 200 looms, under the management of Mr. Jas. Webster, of Dundee. It again collapsed in 1885, and was bought by the Parsee, Mr. Chunda Ramjee, who, after making a fortune out of it, sold it in 1890 to the Central Jute Mill Co., Ltd., of which Messrs. Andrew Yule and Co. are agents.

The Kamarhatty Mill was floated in 1878 by Messrs. James Jardine, Skinner and Co., of London and Calcutta, and originally contained 202 looms. It has this peculiarity that it started on a capital of Rs. 400,000, the rest of the money required for construction being raised on debentures and loans which have now been paid off from profits. It can therefore pay large dividends on very small earnings. It now contains 1,637 looms and 6,096 spindles.

The Titaghar Mill was floated in 1882, and was the second Dundee concern, and it is said to have been paid for out of the surplus profits of the Samnuggar Mill. Its agents are Messrs. Thomas Duff and Co., Ltd. It originally contained 260 looms, but the number has recently been increased to 1,718 looms and 8,800 spindles.

The Kanknarrah Mill was floated in 1882 by Messrs. Jardine, Skinner and Co., of Calcutta and London, and its share capital is chiefly held in Calcutta. It originally contained 320 looms, but has now 1,521 with 7,240 spindles.

The Victoria Mill was floated in 1882 by James Luke, Junr., of Dundee, but owing to a long litigation with the Samnuggar Company, which cost the latter about Rs. 100,000, it did not commence work till about the year 1886. The cause of the litigation was the mistaken idea that the proximity of its proposed site to the Samnuggar concern would injure the latter's labour supply. By the irony of fate, the management eventually fell into the hands of Thomas Duff and Co., Ltd., the agents of the Samnuggar Co. The mill had originally 168 looms, and has now 1,053 with 5,700 spindles.

The Hooghly Mill was floated in 1882 by Messrs. Gillanders, Arbuthnot and Co., and had originally 300 looms, which have since been increased to 455, with 9,236 spindles. For long it had trouble with its engine and also with its workers, and its management got into bad odour with the rest of the agents as they refused at the last moment to join in the short time movement of 1886 to 1890. In spite of running full time their profits were much under the average of the other mills. A second mill containing 360 looms and 7,200 spindles was erected last year, part cost of which was defrayed from a so-called accumulated reserve fund.

MORE SPINDLES FOR CALCUTTA JUTE TRADE.

The following new mills are said to be in course of erection:—

Mill and Managing Agents	Capital (Rupees).
Behar—H. V. Low and Co.	1,400,000
Benjamin—B. N. Elias	5,000,000
Birla—Birla Bros.	2,500,000
Century—Gillanders, Arbuthnot and Co.	5,000,000
Craig—Begg, Dunlop and Co.	6,000,000
Hukumchand—Scrupchand, Hukumchand and Co.	8,000,000
Nahapiet—T. M. Thaddeus and Co. ...	900,000
Orient—Andrew Yule and Co.	10,000,000
Waverley—Begg, Dunlop and Co. ...	3,000,000
Rupees	41,080,000

Taking the value of the rupee at 2s., the capital involved is about 4 millions sterling. Some of these mills will not be finished before two or three years time. Before the war there were 46 jute mills in Calcutta and environs. They spun 5 million bales of jute out of a crop of 8 or 9 million bales. Dundee is only using about 1 million bales per annum.

JUTE CULTIVATION IN BURMA.

A correspondent of the *Times* Trade Supplement states that samples of jute grown in Burma have been submitted to experts in Calcutta, who reported favourably on their quality. As a result of inquiries made in Rangoon as to whether firms in that place would buy jute if its cultivation were extended, there seemed to be no reasonable doubt that, if jute grown in Burma could be landed in Calcutta or the United Kingdom at a price which would compete with that

of Bengal jute, it would meet with a good demand. If jute of good quality can be grown extensively in Burma at the right price, it is very probable that jute mills would be erected in that province to deal with it and to ship jute goods to overseas markets, whose demands appear to be on an ever-increasing scale.

FLYING SHUTTLES.

A shuttle never flies out of the loom without cause, but it is sometimes hard for the tenter to locate the trouble.

The causes of shuttles flying out are numerous and sometimes irregular. At times a shuttle will fly out of the shed repeatedly and then it will run for hours before it will again leave the loom.

In looms of all sorts, a broken thread in the shed will often throw out the shuttle.

In overpick looms, if the picker spindle is not exactly parallel and the picker consequently does not give the shuttle a straight blow, the shuttle will fly out of the loom bang off. Sometimes the hole into which the tapered end of the spindle fits is a little too large, and as the picker moves backward and forward on the spindle the latter moves also, imparting an uneven blow to the shuttle, and thus causing it to fly out. Also if the spindle hole of the picker is not perfectly reamed out, the shuttle may be caused to fly out. The sweep of the strap has also an influence on the movement of the shuttle. If the strap is made so short that the blow of the picker ball is immediately communicated to the picker stick, the movement of the shuttle will be jerky, and it will be occasionally thrown out. The sweep of the strap should be sufficient to impart the blow of the picking ball gradually to the picker stick. The slack of the strap is first taken up by the blow and then the force is imparted to the picker stick, with the result that the blow of the stick on the picker and shuttle is free from jerkiness. In all sorts of looms, if the reed does not form a perfectly straight line with the back of the boxes, the shuttle will be deflected from a straight line and thrown out of the shed. A straight-edge laid from box to box will always tell whether the reed is out of truth or not. A bent dent in the reed will deflect the shuttle from a straight course and cause it to leave the shed. A worn raceway will also cause trouble and occasionally throw the shuttle and the only cure is to take it out of the loom and have it planed.

SUGAR BAGS FOR CUBA.

The sugar exporters of Cuba use large quantities of gunny bags, size 29 in. by 48 in., which come from India. The

total importation of these in 1917 exceeded $5,000,000 in value. The business of supplying these bags is in the hands of a few British and American agents located in Havana.

JUTE SUBSTITUTE FROM STRAW.

The Germans claim that the following method enables straw fibre to be used as a substitute for jute:—

The raw material, e.g., dried rye grass, is placed in a wood or iron vessel provided with a heating device, and over it is poured a solution of caustic soda of a strength of $\frac{1}{2}^{\circ}$ Bé. The solution is left until the plant mucus is dissolved and the straw can be split up into its constituent fibres. The dirty lye is then run off and a cold caustic soda or potash lye of 15–20° Bé or stronger is poured on to the grass. This causes the individual fibres to curl up so that they may be separated. The fibres are then rinsed in hot water. On to the fibres thus treated a 1 to 2° Bé solution of HCl is then poured to remove the salicylic acid in the straw. This process must be carried out in a wood or lead lined vessel and may be either cold or hot. Finally the fibre is washed and neutralized with water containing a little ammonia or magnesium chloride.

NEW USES FOR JUTE.

There is no doubt that jute is now being used pretty largely, especially on the Continent, for much superior manufactures than those for which it has been heretofore utilized. For instance, dress piece goods are being woven with cotton warps and jute wefts, the result being a fabric which dyes much better than linen and does not annoy the wearer by wearing too long.

It is said that some refugee Belgians have induced some Yorkshire woollen manufacturers to part with a large sum of money for the sole right to mix their chemically treated jute with wool in the carding. It seems to us that we are selling a still cheaper material which would answer the same purpose.

PULLED UP JUTE BAGGING.

According to the *Waste Trades World*, jute bagging, torn up by a knot breaker and Garnett machine, is used for several purposes. Mixed with cleaning waste it is used in stuffing mattresses, also for saddlers' work, horse collars, &c. The pulled up bagging may also be respun by special machinery into coarse yarns. In Dundee, some spinners tear up Surat bagging or tares and hessian tares from cotton bales for respinning purposes.

ANSWERS TO QUESTIONS ON JUTE WEAVING.

The following are a few of the questions set at the recent City and Guilds examination in the above subject:—

(1) *Question.*—Discuss the relative advantages of the types of shed produced by (*a*) a negative wyper and (*b*) a Parker dobby.

Answer.—A negative wyper produces an open shed, while Parker's dobby produces a positive centre shed. In open shedding the warp threads remain in their highest or lowest position in the shed for as many shots as the pattern demands. In centre shedding, the normal position of all the warp threads lies in the line passing over the warp rail and breast beam. To form the shed, some of the warp threads are raised and others depressed. When the pick has taken place the two sets of threads come together again in the centre ready for the next division of the warp. In open shedding, the shed is always open. The threads required to change from the upper line are depressed, while those required from the lower set are raised and so on after each shot of weft. Open shedding saves time and power.

(2) *Question.*—Describe a positive up-take motion. Give the value of the wheels, &c., arranged to give 6 shots and 20 shots per inch.

Answer.—An intermittent positive up-take motion often employed consists of a train of five wheels, but sometimes of three or seven, the first being a ratchet wheel and the others a pinion termed the change pinion, an intermediate wheel, another pinion which may also be changed and a wheel keyed upon the arbor of the cloth roller or sand beam. The ratchet wheel is rotated by means of a pawl attached to a lever arm and which may give a variable throw. Usually the ratchet wheel is moved one tooth at a time, i.e., one tooth for each stroke of the sley.

The product of the number of teeth in the ratchet wheel, intermediate wheel, and roller wheel divided by the product of the number of teeth in the change pinion, intermediate pinion and the circumference of the cloth roller equals the shots per inch. Thus suppose the ratchet wheel has 40 teeth, intermediate wheel 80 teeth, and roller wheel 80 teeth, while the change pinion has 30 teeth, intermediate pinion 40 teeth, and diameter of the cloth roller $5\frac{1}{8}$ in. The shots per inch would then be

$$\frac{40 \times 80 \times 80}{30 \times 40 \times 5\frac{1}{8} \times 3{\cdot}1416} = 13{\cdot}24 \text{ shots per inch.}$$

The change pinion required may be found by dividing the product of the teeth in the ratchet wheel, intermediate wheel and roller wheel by the product of the number of teeth in

the intermediate pinion, shots per inch required and circumference of the sand or cloth beam. Thus, to obtain 6 shots per inch the change pinion required to work in conjunction with the above wheels, &c., would be $\frac{40 \times 80 \times 80}{40 \times 6 \times 5\frac{1}{8} \times 3 \cdot 1416}$ = 66. While to put in 20 shots per inch a pinion of $\frac{40 \times 80 \times 80}{40 \times 20 \times 5\frac{1}{8} \times 3 \cdot 1416}$ = 19 teeth, would be required.

THE JUTE TRADE SWAN SONG

That ended in Resurgent Chorus—The Calcutta Bogey.

It has not infrequently happened in the history of the Dundee jute trade that when those engaged in it had begun to sing its swan song it was found, after a stave or two had been rendered, that circumstances made it more appropriate for a resurgent chorus. One such episode of a particularly striking nature occurred in the early part of 1919. For a time following the cessation of hostilities outward indications pointed to hard days being in store for the industry. The Government had stopped, or greatly reduced, their orders for manufactured goods, and commercial orders fell to a minimum. The consequence was that many establishments in the city had to resort to alternate week stoppages, and during the idle weeks between £20,000 and £30,000 had to be disbursed in out-of-work benefit.

Demand for Inquiry.

A demand was made for a Government inquiry, and the Board of Trade sent down a Committee of three—Mr. George Malcolm, Mr. E. F. Crowe, and Mr. T. M'Kerrell—to carry out investigations into the existing state and future prospects of the trade.

Hardly, however, had the Committee begun its deliberations in May when things began to take a remarkable turn for the better, and this pleasing development has continued ever since, the difficulty of late being not to find work for the workers, but workers for the work that fails to be overtaken, at "a satisfactory margin of profit."

But despite this remarkable revival, which is still running strong (spinners having recently orders which would keep them going for a year), there is always the bogey of Calcutta competition in the offing. But the Committee do not offer

any effective means of laying it. The best they can say is that "endeavours should be made to extend the manufacture of specialities in Dundee, and research would help in that direction."

Impractical Proposals.

The only solution proposed by the employers was the prohibition of the import of manufactured jute from India into this country. The proposal appeared to the Committee to be impracticable. The solutions proposed by the Trade Unions were (1) that the wages of the jute operatives in India should be raised to the equivalent of the wages in Dundee by the adoption of a Trade Board Act in India, and (2) the extension of the British Factory Act to India.

With regard to the first of these proposals, the Committee did not think that it was a practicable proposal to raise wages in India to the level of those being obtained in Dundee. With respect to the second, the framing of the Factory Act in India was a matter for the India Office, and, even though on other grounds the British Factory Act was applied to India, it did not appear that it would have an appreciable effect on the question under consideration.

No Protection.

On the whole question of Indian competition the views of the Committee are summed up in the following notable paragraph:—

The Committee are unable to recommend artificial means to enable the United Kingdom to compete with another portion of the Empire, and are of opinion that the industry should be informed as soon as possible that action in the direction of protecting the jute industry against the competition of India is impossible, and that it rests with the manufacturers engaged in the industry to take the necessary steps to economize working expenses to the uttermost, and to develop the production and sale of the kind of jute manufactures which are not at present manufactured in India, and which are unlikely to be produced there in future.

DECREASED ACREAGE UNDER JUTE CROP.

(*Board of Trade Journal*, 1918.)

The Director of Agriculture, Bengal, has published a preliminary estimate of the areas under jute for 1918 in the three Provinces of Bengal, Bihar and Orissa, and Assam. The total acreage in this estimate is 2,491,703, which repre-

sents a decrease of 244,296 acres, or about 9 per cent. on last year's final figures.

The difference between the preliminary forecast, 1918, and final forecast, 1917, by Provinces, is:—

Bengal (including Cooch Behar)	161,591
Assam	10,000
Behar and Orissa	72,705
Total ...	244,296

Bengal.

The return shows a total area sown of 2,250,836 acres, being a decrease of 161,591 acres, or about 7 per cent. from last year's final figures. The large decrease in area reported from some districts may be attributed to the low price obtained for last year's crop and the large carry-over.

The area has been well maintained in the more important jute-growing districts in Eastern Bengal, viz., Dacca, Faridpur, Mymensingh and Tippera, the two former showing considerable increases over last year's figures. The crop may be rated as "fair" only, and is on the whole inferior to that of last year at the time of the publication of the Preliminary Forecast. A large balance from last year's crop is still held in the districts, especially in Northern Bengal.

Behar and Orissa.

The total area under jute as reported by the District Officers is estimated in round numbers at 150,600 acres, as compared with 223,300 acres of last year. The decrease is due to the low price of jute last year, and also to apprehension of increased trouble in selling this year owing to a diminution of railway facilities. The condition of the crop is not promising in Cuttack and Purnea; elsewhere it is fair to good.

A large quantity of jute from the crop of 1917 remains in Purnea. In other districts the stock of last year's crop is small.

Assam.

As estimated by the Deputy Commissioners, the total area of the Province is calculated to be 90,300 acres, or 10,000 acres less than the final revised figures of last year, and 13,600 acres more than in the preliminary forecast of last year. Goalpara and Sylhet, the two principal jute-growing districts, are responsible for the decrease, on account of the unfavourable market outlook.

It has been reported that little jute remains in almost all districts, but in the Sadar subdivision of Goalparat practically the whole produce of last year still remains with the traders, the reported cause being insufficient transport.

SOME MAKES OF JUTE BAGS.

Australian twill (small),	8 por., 9 shot, $2\frac{1}{4}$ lb., 41 by 24 in.
Bombay and Karachi twill,	6 por., 8 shot, $2\frac{1}{4}$ lb., 45 by 27 in.
Chilian Wheat Barley,	6—8 por., 8—9 shot, $2\frac{1}{4}$—$2\frac{3}{8}$ lb., 45 by 27 in,
New Zealand twill (long),	8 por., 8 shot, $2\frac{3}{4}$ lb., 48 by 28 in.
Calcutta Gunny,	$5\frac{1}{4}$ por., 7 shot, $1\frac{5}{8}$—$1\frac{3}{4}$ lb., 48 by 28 in.
Californian Central,	11 por., 12 oz., $\frac{3}{4}$ lb., 36 by 22 in.
River Plate Narrow,	11 por., 12 oz., $\frac{3}{4}$ lb., 40 by $22\frac{1}{4}$ in.
American Flour, 140 lb.,	11 por., 12 oz., $\frac{7}{8}$ lb., 40 by 24 in.
American Flour, 280 lb.,	11 por., 12 oz., varies, 53 by 29 in.

The cotton gunny bags are plain and unhemmed. The last three are selvedge and the others are hemmed.

COST OF AN INDIAN JUTE MILL.

In India, a mill building to contain 400 looms cost pre-war about £25,000, and warehouses for jute and finished goods probably another £7,500. A mill manager's house and overseer's barracks would run to another £1,500, and jetty, tramway, &c., also £1,500. The cost of 400 looms, with all the necessary preparing and spinning, engine power and accessories, delivered and erected, cost pre-war £100,000, making the total cost of a 400-loom mill about £140,000.

INDIAN JUTE TRADE IN 1916.

According to the Report of the Director of Statistics to the Indian Government, reviewing the trade of British India in the year ended March 31, 1916, the exports of raw jute in 1915-16 amounted to 3,360,633 bales, valued at 156,400,000 rupees, as compared with 2,828,532 bales, valued at 129,100,000 rupees, in the previous year. The increase was, therefore, 19 per cent. in quantity, and 21 per cent. in value. By far the largest quantity went to the United Kingdom, which increased its demand for this material, as did also the United States, Italy, Spain and Brazil. The quantity and value of exports of raw jute to the principal importing countries were as shown in the following table:—

To	1914-15 Quantity Tons	1914-15 Value Rupees	1915-16 Quantity Tons	1915-16 Value Rupees
United Kingdom ...	266,000	67,400,000	339,000	92,300,000
United States ...	81,000	13,300,000	107,000	21,700,000
Italy	42,000	11,200,000	61,000	16,800,000
Spain	25,000	5,800,000	39,000	10,300,000
France	34,000	8,600,000	30,000	8,700,000
Brazil	1,000	300,000	9,000	2,600,000
Japan	3,000	800,000	5,000	1,100,000
Russia	4,000	1,300,000	3,000	1,000,000
Other countries ...	49,000	20,400,000	7,000	1,900,000
Total ...	505,000	129,100,000	600,000	156,400,000

During the year 1915-16 there were 70 jute mills in British India, employing 39,890 looms and 812,421 spindles, as compared with 37,830 looms and 795,528 spindles in the preceding year. The exports of gunny bags and cloth from British India in 1915-16 reached a record figure. The number of bags exported was 794,000,000 as compared with 398,000,000 in the previous year, and the value of these exports was 201,500,000 rupees and 125,900,000 rupees respectively. Exports of gunny cloth in 1915-16 amounted to 1,192,000,000 yards valued at 176,700,000 rupees, as compared with 1,057,000,000 yards valued at 131,100,000 rupees in the preceding year. (Rupee, 1916 = 1s. 4d.)

CABUYA FIBRE INDUSTRY OF ECUADOR.

"Cabuya" fibre is produced from different districts in Ecuador, principally from the neighbourhood of Ibarra. The fibre is employed for making "alpargatas" (sandals), rope, string, bags, &c.

Supplies of sacks are obtained from a factory recently established at Duran, and also from the interior towns of Ambato, Guano, &c., where they are made by hand; but the total output is not large. The aggregate output of "Cabuya" sacks averaged 30,000 per month during the last six months.

It is considered that "Cabuya" is in the nature of a temporary industry and is not likely to become an important article of export. It has received its impetus from the difficulty of obtaining jute supplies rather than from artificial war values. According to the manager of a company at Quito, the plant takes six years to mature properly, and the return on it is barely sufficient to recompense the grower and to encourage him to extend cultivation.

At present it is being used for cocoa, coffee and sugar sacks, but it is so inferior and its price is very little less

than that of jute, that firms which have been exporting in "Cabuya" sacks will probably discontinue doing so.

As regards its use for the manufacture of rope or cord, "Cabuya," it is stated, is well suited for the purpose; nevertheless, local production is so small that the actual requirements of the country cannot be supplied, and similar goods continue to be imported into Ecuador from the United States, even at war prices.

The cost of a "Cabuya" sack at the present time is 5s. 6d. —as compared with 6s. 0½d. for a sack made of jute.

PROGRESS IN THE CULTIVATION OF JUTE IN INDIA.

(*Board of Trade Journal*, 1917.)

The importance of jute to the prosperity of Indian agriculture is evident from the fact that in the year ended March 31, 1917, the value of the exports of raw and manufactured jute amounted to 25 per cent. of the value of the total exports of Indian merchandise, the highest percentage represented by any single commodity. At present its cultivation is confined to Bengal, Assam, and part of Bihar. There were 2,702,000 acres under this crop in the year 1916-17, an increase of 326,800 acres, or 14 per cent. over the 1915-16 figures. The total out-turn (8,305,000 bales) exceeded that of 1915-16 by 964,700 bales, or 13 per cent., but the yield per acre was 5 lb. less, although 126 lb. more than that of the last decennial period.

Recent Experiments.

India having practically the monopoly of this important requisite of international commerce, the supply is not in proportion to the demand, and the problem before the Department of Agriculture is to increase the output, both by extending its cultivation to other suitable areas, and by improving the quality and yield by better cultivation, evolution of better varieties and seed selection. This work is mainly in the hands of the Government fibre expert.

Several promising new varieties of capsularis and olitorius jute have been selected, and they are being multiplied. Meanwhile, trials at a number of different centres on land lent by several jute firms confirmed the opinion previously expressed that Kakiya Bombai is a heavier yielder than the varieties commonly grown by the *raiyats*. These tests showed an increase of over three maunds of fibre in favour of the Kakiya variety.

Distribution of Seed.

The distribution of the seed of this variety has been taken in hand by the Department of Agriculture, and is assuming the proportions of an industry. The work is being done through the panchayets, and at the commencement of the 1916-17 season over 30,000 packets of seed (each containing $\frac{1}{4}$ lb.) were distributed in the Dacca and Mymensing districts. If successful, this should have produced seed for over 30,000 acres in 1917-18, as the growers were asked to retain it for use in the current year. The Department hoped to have about 5 lakhs of packets available for distribution, and it was proposed to distribute the whole amount on the above system. By this means it is hoped that in a few years time all the growers of capsularis jute will have the opportunity of seeing and testing Kakiya Bombai for themselves.

Local Sources of Potash.

By the application of potash manures to jute on red laterite soils the crop responds readily. The timely discovery that the pernicious weed, water hyacinth, which grows luxuriantly in the bhils and khals of Bengal, contains a large percentage of potash, has made available to the cultivators the cheapest possible manure, and will go a long way towards solving the problem of supplying this soil constituent.

Much valuable information has been obtained regarding the incidence of disease and the varying behaviour of different races of jute under adverse conditions. The most noteworthy conclusion in this connection is regarding the prevalence of the Rhizoctonia disease in jute grown on soils deficient in potash and the effect of potash salts as a preventive of this disease.

In Burma experimental plots of jute are being grown in Delta districts with a view to test the suitability of that tract for this crop.

Chinese Jute.

According to the returns of the Chinese Maritime Customs, the export of jute from China amounted to 96,481 piculs (picul = 133$\frac{1}{3}$ lb.) in 1916. Of this amount 67,000 piculs were shipped from Tientsin, North China; 15,000 from Hankow, Central China; and 13,000 from South China. A small amount was also exported from Manchuria.

It is probable, however, that a considerable proportion if not all of this "jute" is in reality "Abutilon" hemp, the two plants being constantly confused by the Chinese.

The Ministry of Agriculture in Peking can give no information which locates the area of production of jute with any

accuracy. According to the catalogue of the Vienna Exhibition, jute fibre is produced in China and is exported from Shanghai. Loureiro mentions it as being cultivated near Canton, and Dr. Faber in the Province of Szechuan. It is also believed to be grown in the neighbourhood of Ichang in the Yangtse Valley.

JUTE SPINNING IN INDIA.

Jute was known to the natives of India in a comparatively remote period and about seventy years ago the poorer people were largely clad in jute cloth of home manufacture. There are now approximately 35,000 jute looms and 706,500 jute spindles at work in Indian mills. They produce over 450,000,000 jute bags and nearly 1,000,000,000 yards of jute cloth per annum. The total number of hands employed in the Calcutta mills is approximately 203,000, of whom 10 per cent. are children under 14 years of age.

With one or two exceptions the mills are erected on the shed system, and situate in spacious compounds or enclosures, and have fine river frontages. The Victoria Mill, for instance, has a compound of about 40 acres. A new mill costs about £270 per loom to erect and start (pre-war figures).

There are no better workers in the world than those in the Calcutta jute mills. A paternal despotism suits them exactly. Whenever they get to believe in their manager as one who will be kind though firm to them, who, while demanding absolute obedience, will give them absolute fair play, their loyalty is secured. The mills are all wrought upon the shift system, but no individual man or woman works more hours per week than the corresponding class of worker does at home. The weavers are all men—one man per loom. When a weaver goes away to a meal, his neighbour keeps his loom on until his return, and then the compliment is returned. When working full time the mill engines run from daylight to dark six days per week, cleaning and repairs being done on Sundays. On the average the week was 72 hours as against 55 in Dundee. The wages paid seem ridiculously small to us. Carders earned 1s. 6d. per 72 hours week, preparers, 1s. 5d. to 2s. 3d.; spinners, 2s. to 2s. 6d.; shifters, 1s.; native foremen, 3s. 9d. to 5s. 5d.; labourers, 1s. 10d.; weavers (average), 4s. 2d.; tenters, 4s. to 7s. The workers are nimble and expert—the shifters quick. Living is so cheap that the workers thrive and save money on their wages.

European managers and foremen are well off in Calcutta. The manager generally has a fine, large, commodious bungalow for his own use. The assistants' quarters consist, in most instances, of a spacious two-storeyed house, each of the

six or eight men having a good-sized room, with bathroom attached exclusively to himself. These rooms are furnished by the company, but the furniture is always added to by the occupants—a piano being no uncommon article of furniture. Each of the houses has a large common dining hall and a billiard room. His food costs him about 9s. per week. His other necessary expenditure is about 3s. per week to his native bearer, who helps him off and on with his clothes, attends him at table, stirs his tea and lights his pipe. He pays about 3d. per week to the sweeper for attending to his fox-terrier, and when he keeps a horse and trap, as he sometimes does, in partnership with another, it costs him about 4s. 6d. per week. He pays no house rent and gets free medical attendance. Should he fall ill, he is sent down to the private ward in a Calcutta hospital, which he is loath to leave as the Eurasian or half-caste nurses are so kind and winsome in their ways. When he comes out of hospital he is either sent for a fortnight up to the hills or to Ceylon, a five days' journey by steamer. This latter trip extends to about three weeks. He is on full pay all the time and the company pays all his expenses.

The jute mill assistant generally starts on a pay of Rs. 200 per month with £6 out of this sum paid at home at the par of 2s. per rupee. The monthly rise during each succeeding year of the term of his engagement is usually Rs. 25. In addition to his pay most of the mills give a bonus, sometimes calculated on the turn-off and sometimes on the profit available for dividend, this bonus often amounting to half their fixed wage. When he gets up at sunrise in the morning his attendant brings him a cup of tea with some toast and sometimes a couple of eggs. This corresponds with the French *petit déjeuner.* When his real breakfast time comes, he sits down to several courses. The "peg" is a great Indian institution. It is the first and last thing you are offered in an Anglo-Indian house. It consists of a glass of whisky, a bottle of soda water, and a lump of ice, all tumbled into a tall glass. It is responsible for the downfall and early death of many a fine promising young Scotchman. Young men going out to India should beware of the "peg." They do not require it. The healthiest men in the jute mills are total abstainers. Luncheon or tiffin takes place when he is given a two-hours' rest in the middle of the day. He then takes a sleep before commencing his afternoon's work. At four o'clock his bearer takes him a cup of tea, and when the day's work is over he sits down with his fellows to his evening meal. Afterwards he has a game of billiards or reclines in a long chair with a cigar and reads his *Advertiser* or *Courier.* By ten o'clock all are in bed. On Sundays he pays visits among his friends and plays cricket and lawn tennis.

The mill manager in Calcutta has a better job of it than in Dundee. He has a beautifully furnished bungalow and has quite a retinue of servants to attend him. His wife has her weekly "At homes." He has his horses and carriages. She drives out in her brougham. The policy of the mill is directed by the manager, as the Calcutta agent has usually slight acquaintance with the practical working of the mill. Managers are well paid out there. There are not many under Rs. 600 a month, while Rs. 800 is quite common. A commission carrying from 1 per cent. to 2½ per cent. is a common enough addition to a manager's stated salary. When times are good some of them draw no less than Rs. 1,500 a month in all.

The commercial management is in the hands of Calcutta agents. A good feature about Calcutta jute mill management is the monthly profit and loss statement. The cost of production is carefully tabulated under all the various heads of which it is composed, so that it may be seen at a glance if there is any increase or decrease going on from month to month, and at the end of every month a statement is made showing how much the mill has made or lost during its currency.

The remuneration which the agents receive for management varies considerably. Nearly all of them get a percentage on the gross sales, 2½ per cent. being common.

The Calcutta jute mills enjoy an enormous advantage over all their competitors in other countries by being in the home of the raw material. No other country can compete with Bengal in the production of the fibre. The capability for producing jute in Bengal is practically illimitable. There is no fear of the demand overtaking the supply. Every year new territory is being put under cultivation.

In the Calcutta jute mills everything is hard driven. The spindles and looms are run even faster than in Dundee. There is an ample supply of native coal brought from the Raneegunge district, about three hours by rail distant. It costs about 8s. per ton. At more than one mill the coal contractor is content to make up his monthly coal bill based upon the total output of bags, charging for, say, 12½ cwt. of coal for every ton of bags produced.

THE JAPANESE JUTE INDUSTRY.

Schemes for Expansion.

In the course of an article on the growth of the Japanese jute industry, the *Board of Trade Journal* says that up to the war the demand in Japan for gunnies had been more or less steady, but the rapid development in the export of beans, peas,

rice, &c., to the Allies brought about a corresponding increase in the demand for gunnies for packing purposes. Other uses to which jute products are put in Japan include hessian cloth for packing covers for the cotton yarn export trade, and jute canvas and brattice cloth for use in mining. A rug industry is carried on at Sakai, near Osaka, where old bags are made up into cheap rugs. For better quality rugs fresh twine is used.

Up to 1918 the manufacturers of jute products from raw jute had been limited to one factory in Japan—the Koizumi Jute Mill at Togahama, near Kobe, and one in Formosa. The Koizumi Mill is a private concern, belonging to the Koizumi family, and was erected in 1890 with the object of supplying the demand for bags for the rice export trade. The factory has since been doubled in size, and its products comprise yarn, twine, hessian cloth, gunny bags, and canvas.

The manager has spent a considerable time in mills in Calcutta, Dundee, Hamburg, and Bonn. He expresses the opinion that, so far as output is concerned, five Japanese workmen are equivalent to about three Europeans, and five Indians to about 4½ Japanese. The mill consumed in June, 1918, from 2,000 to 3,000 bales per month, of which about one-third was used for gunnies, the same for hessian cloth, and the same for yarn. The jute used was from Narraingunge. The factory is to be extended four times its present size, and a large quantity of machinery is on order. Recently several other concerns have been turning their attention to the jute industry, and two appear to be definitely decided to start operations.

There seems to be little doubt but that the new concerns, in addition to supplying the local demand, have in view a possible export trade. The demand in Japan itself cannot be more than about 5,000,000 bags per annum, and, although this figure was increasing in 1918, it is doubtful if it will be maintained now that war is over. Hessian requirements will no doubt increase with the growth in the cotton yarn export trade. In Manchuria there is a demand for about 12-15,000,000 bags per annum for the soya bean trade.

JUTE SPINNING IN GERMANY.

The German jute industry dates from 1861, when Mr. Julius Spiegelberg began to spin jute in Vechelde with about 1,000 spindles. A Scotchman, Mr. Maxwell, accepted the management, and Scotch spinners taught the Germans. As, however, a prejudice existed against jute at that time, it was not possible to raise sufficient working capital in Germany. Foreign capital was sought, and a limited company estab-

lished under the title "British and Continental Jute and Flax Works Co., Ltd.," in Brunswick, with Mr. Spiegelberg as director. Good profits being realized some German-owned mills sprang up and Scotch workers were well paid to teach the Germans. These mills were principally erected in suburban villages. The mill-owners built workers' houses, and let them to the hands at 2s. to 3s. 6d. a week. Besides these houses, which are built very neatly, schools were erected for the mill children and teachers supplied. Kindergarten and crèches were established for the very small children during the time their parents were working in the mill. Special nurses were engaged to watch the little ones, who got fresh milk thrice a day at the expense of the Company. Sixty hours per week are worked.

JUTE CURRANT AND TOBACCO BAGGING FOR GREECE.

Greece is stated to require at least 500,000 export currant bags per annum. A good brand of bagging, running about 16 threads per inch, is required for this purpose.

For the tobacco trade, bagging about 25 in. wide is required. It varies in fineness from 16 to 22 threads per inch. Large quantities of twine are also required for use with the above.

THE JUTE INDUSTRY OF BRAZIL.

Owing to the enormous quantities of jute bags, &c., used in South America the Brazilian Government is very anxious to encourage the growth and manufacture of jute in that country, where at present there are only a few small mills. The Minister of Agriculture has been conducting experiments in the low-lying lands of the State of Bahia and in some of the districts of San Paulo, and these experiments have given promising results and are said to prove that jute can be advantageously cultivated in Brazil. Owing to the shortage of jute brought about by lack of shipping space during the war and to the greater need for that material, due to war conditions, felt by the sack makers of Brazil, Arimina fibre and that of the Conhams Braziliensis Perini have been tried as substitutes, but without very satisfactory results.

Jute is an extremely important textile in South America, and Brazil at least has attempted to establish a jute industry of its own. In order to assist this young industry the Minister of Agriculture of Brazil recently dispatched two emissaries to India. On returning to Brazil these two gentlemen supplied reports. One declared that it was hopeless to consider the growing of jute in Brazil, while the other was

equally emphatic that excellent jute plantations could be developed there and the fibre obtained economically. It would appear, therefore, that there will be little local production of jute, and that, as before the war, its cultivation will be a monopoly of the British Empire. We must, therefore, remain the suppliers of jute to South America, whether the supply be as fibre, yarn, cloth or bags. In 1913 South America took jute yarns of no less than £358,000 value, or 45·8 per cent. of our exports (Brazil alone took 38·2 per cent.), 15·4 per cent. or £471,000 of piece-goods, 8·25 per cent. or £37,000 of unenumerated jute fabrics, and 35·4 per cent. (Argentina alone took 26 per cent.) or £433,000 of bags and sacks. Thus in 1913 South America purchased £1,299,000 of jute manufactures, or 24·2 per cent. of all our jute exports. An interesting, and we consider a very unfortunate, feature of our pre-war trade with South America was the fact that most of the British jute trade with that region was carried on by Hamburg shippers. Our only possible competitor in this market is India. Coarse fabrics and bags can be supplied from Indian mills, but Dundee is still likely to hold her own with high-grade hessians, linoleum cloths, sugar bags, and other fine specialities.

THE JUTE TRADE—PAST AND PRESENT.

Early in the nineteenth century school geographies remarked of Dundee: "Dundee carries on a very flourishing trade, chiefly with the Baltic, and has extensive manufactures of Osnaburg and other coarse linens. Pop. 45,355." At that time, jute was an unknown fibre in Britain, while our colonies were mostly wild wastes. The extensive manufactures spoken of might easily have been produced by an average-sized factory of the present day. It was in 1835 that jute was first introduced into Dundee where it has become the staple industry. The demand for jute, in spite of remarkable expansion in its cultivation in recent years and the occasional rise in prices to an unprecedented height, still continues very keen and consumption is very near outstripping production, jute fibre being put to an increasing number of uses every year. Its adaptability was soon made manifest in Dundee and its cheapness commended it as a good subject for experiments, with the result that might well surprise the pioneers could they see it now. For not only is it the universal packer, but as an adulterant has become famous.

The machinery then existent in Dundee could with little alteration soften, card and sliver jute. But it was some time before the warp could be used without starching. After a time this difficulty was overcome, and even the power-loom,

with its rapid pick, could go on without undue breakage by the gatherings caused by friction of reed and heddles. Then hand-looms received their death-blow, although they lingered on in a languishing state for many years afterwards.

It was early discovered that jute could take on a brilliant dye and this led to carpet weaving—one of the earliest products—and one of the most successful, and at the present time the world is well laid with Dundee carpets. Heathfield was the nursery ground of this industry. The high-class warehousemen would have none of them for a time, but when Brussels and velvet were successfully imitated, they were compelled to go with the times, and now where wool ends and jute begins requires the skill of an expert to determine.

The Crimean war, like the present war, so disastrous to our poor soldiers, was a decided Godsend to Dundee, and coming as it did after the crisis of the early forties, mills grew apace and power increased—even hand looms had to be called back to life—and all went merry as a marriage bell. When it was all over a severe reaction set in. Many wished for another good war, even if they did not openly express it. From the end of 1854 till the American war, Dundee came through one of its most severe crises. Only a few of the best houses and some of the most saving little ones were able to stand the blast. Some good old firms had to go, and some were saved only by the skin of their teeth. Ten per cent. was a frightfully eating charge for accommodation—and that only on undoubted security. The warehouses were full of mortgaged goods. Banks helped all they could without risk of loss, and those who had money to loan were the only profiteers.

After the Indian Mutiny was ended and the American war had begun there was a boom in all kinds of jute fabrics. Little mills grew into big ones, and big ones doubled their power, and new ones rose up like mushrooms. There never until recently were such times. 10½-oz., 40-in. hessians now touched 5d. per yard, worth in 1897 1¾d., and other things were in proportion. Consignments were made to the States of the most incongruous character, from "grunt"—mending bagging to scrims—anything that might be converted into sand-bags or for commissariat work. Fortunes were made, and, strange to say, wages continued wonderfully low, and, stranger still, without much agitation to have them increased. In 1857 warehouse girls got 4s. 6d. to 5s. per week, and men 12s. to 15s. for a longer week than now prevails and yet they seemed for the most part comparatively happy. When the American war came to an end there was necessarily an accumulation of consignments—mostly rubbish, which had to be sold for what it would fetch—but for all that, on counting up, mostly all engaged in the business came out rich.

The reaction after the American war proved less acute than on former similar occasions. Doubtless that was much owing to the manufacturers' stability. Crises were supposed to come in decades, but after that particular war they became less regular as to time. New colonies were utilizing their resources and new ones were being found for Dundee goods and enterprise, and telegraph cables soon brought about a less erratic demand. But they had had the effect of bringing envious eyes on Dundee's prosperity and gradually continental mills, with Scotch managers and foremen, began to rise in different parts. One or two gave a feeble flicker and yielded up the ghost; but the greater part remained and increased until in every European country jute is manufactured.

About the middle of the sixties Calcutta began to assert herself by providing gunny bags for the Eastern Empire, but she did not long remain contented with that, and speedily absorbed Australia and New Zealand, and their large requirements for wool-packs and three-bushel grain sacks were no longer obtained exclusively from Dundee. Next followed San Francisco, with its 30 to 40 millions of central flour bags. Blow after blow came in rapid succession until it seemed as if every colony had gone over to the enemy. The Suez Canal, too, made it very easy transit from Calcutta to the Levant, and that went too, and all that seemed left to Dundee was the United States and the home trade. Now these have also been assailed, and thousands of bales of Calcutta hessians find their way to New York and not infrequently through Dundee accounts. Happily the margin on this class of goods is not so marked, and Dundee can compete favourably with the advantage of better-liked goods, although lately the Indian qualities have been much improved. At first, native sewn grain sacks showed unmistakable marks of the " 'prentice hand," while the sacking itself was hard and unattractive. However, the latter bad quality disappeared with handling, and Calcutta sacks—London sewn—remain a feature, and have an enhanced value of $\frac{3}{4}$d. per sack over native sewn. Bit by bit prejudice has melted away before cheap price and improvements in quality, and the revolution has been so complete that it is doubtful if a single old conservative buyer of Dundee ordinary goods remains.

INDEX.

John Bale, Sons & Danielsson, Ltd., 83-91, Great Titchfield Street, London, W. 1.